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Dear Nuts & Volts:

I just received my April 2004 issue of *Nuts & Volts* and looked over the “Feedback” from Bob Nelson concerning Michael Kornacker's article, "Learn About Cyclic Redundancy Checks." Nelson mentions having trouble with the math in the examples. Michael does have a response, but he seems to have only addressed part of the problem. The Message (M) in "Example 1" seems incorrect. It is "1000110100000" and should be "101000110100000," as correctly illustrated in the article's text. I found this article very interesting and read it from beginning to end. Your magazine is really great stuff. Keep up the excellent work! Now, back to my April issue. All the best.

Allen Moore
Palm Bay, FL

Dear Nuts & Volts:

In the article "The Colossus Of Radio," by Michael Banks, the sidebar "Those Mysterious Call Letters" infers that the KDKA call letters were from Philadelphia, PA. You have the right state, but they are actually from Pittsburgh, PA. KDKA was originally a Westinghouse station on the western side of the Alleghenies. It still exists today. Otherwise, it was an excellent article. Keep up the good work.

Joe Patay
via Internet

Response:

My apologies for moving KDKA from Pittsburgh to Philadelphia without notifying anyone. Of course, I might claim that the lapse was intentional, in honor of Hugo Gernsback; according to several old-timers who worked for Gernsback magazines — such as *Science and Invention* and *Astounding Stories* — it was common practice among editors to introduce an error or two in every issue. Their readers were a bright lot and enjoyed pointing out mistakes — so the editors gave them something to find. It kept letters coming and readers eagerly awaiting the next issue.

Author Michael Banks

Dear Nuts & Volts:

I'm a 22-year-old computer engineering senior at the New Jersey Institute of Technology. I'm writing to thank the author of "Learn About Cyclic Redundancy Checks" in the March 2004 issue of *Nuts & Volts*.

On the evening I received that issue, I had my digital test night class. The topic of the lecture was CRC (little did we all know that, as we were all so confused). Our professor is extremely intelligent and has a great understanding of the material. The problem is, he doesn't realize that we don't share the same intuition. Most of us — including myself — walked out of the lecture completely confused. Our professor completely neglected to fill us in on the applications of the material in the real world.

I came home and started reading *Nuts & Volts* and was completely shocked when I got to Mr. Kornacher's article. He discussed just about everything we did in class and explained it all so well. The biggest help was being able to trace through his circuits. I went from understanding nothing to understanding everything! I will be passing around the article for my friends to read. I would just like to extend my deepest gratitude to the author.

If you could somehow forward this message to him, I would appreciate it. Thank you and compliments on *Nuts & Volts* — it is a great magazine that I draw so much inspiration from. I have personally found that computer engineering is a very challenging venture; it’s supplemental information from your magazine that makes my life truly easier. Thanks again!

Michael Passaretti
via Internet

Dear Nuts & Volts:

The circuit schematic for the March 2004 “Simple HDD Exerciser” article by Evert Fruitman has a fundamental problem which will cause the timing to be erratic. The cause is the 12 V power supply voltage. Q1 and Q2 in the free running astable multivibrator circuit will both suffer base-emitter voltage breakdown. The reverse Vbe voltage rating for a 2N3904 is 6 V, maximum. Actual breakdown for silicon bipolar transistors is typically around 7 V.

Here is what will happen. Assume the circuit is starting to “flop.” C1 is charged with nearly 12 V across it. When Q1 turns on and reaches saturation, C1 will try to force the base voltage of Q2 to minus 11.5 V or so. The Q2 base-emitter junction will go into zener breakdown, clamping the base at about 7 V and rapidly discharging C1 to this voltage. This is not reliable/stable operation. A simple fix is to add a diode (1N914 or similar) in series with the base of transistors Q1 and Q2 — diode cathode to transistor base. Try it and see.

Here are some guidelines for designing this type of transistor multivibrator:

1. For power supply voltage up to 6 V, use silicon bipolar transistors, as shown.
2. For any voltage larger than 6 V, add the diodes.
3. An interesting option for voltage up to 9 V is germanium transistors without diodes (if PNP, reverse power supply polarity).
4. Forget MOSFETS in this type of circuit; bipolar transistors work much better.

I am an electronics engineer, but I have always enjoyed the hobby aspect of electronics, so I am one of your loyal subscribers.

Ernie Worley
via Internet

Regarding April’s “Techknowledgey 2004,” we would like to assure our readers that the entire column was an April Fool’s joke. Stinky has no current plans to invade Earth. — Editorial Dept.

by J. Shuman

I THINK I'LL KEEP MY THICK SET WITH THE THIN PRICE...

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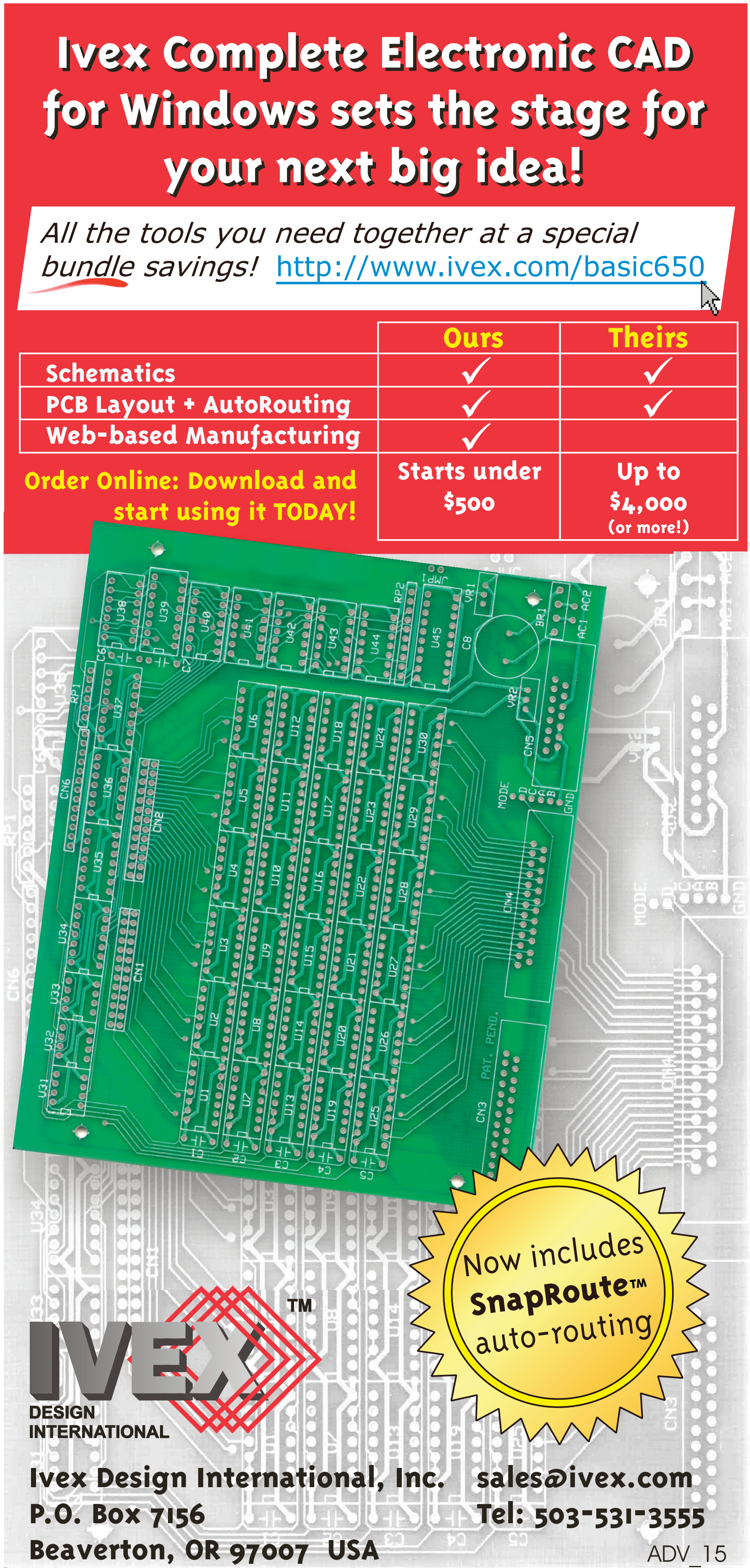


Electronic Theories and Applications From A to Z

Let's Get Technical

Chasing its Tail: A Fiber Optic Ring Oscillator

I have chosen to finish my three-part fiber series with an application that uses a fiber optic cable as part of a high-frequency oscillator. Called a Fiber Optic Ring Oscillator, it makes use of a length of fiber to generate a square-wave signal; the frequency of its oscillation depends on the length of the fiber and the speed of light inside the fiber.

Consider the simple three-inverter circuit shown in Figure 1. Notice that the three inverters are connected in a ring. Now, if we make the assumption that the gate delay for each inverter is identical, we can figure out a few things. Suppose the output sits at a logic zero level when we first turn the circuit on. After one gate delay, the output of the first inverter will go high. After a second gate delay, the output of the second inverter will go low. After a third gate delay, the output of the third inverter (where we started) goes high. The output was low for three gates delays. Now, the high level on the output makes its way through the three inverters — requiring another three gate delays — and the output of the third inverter goes back low again.

We have just completed one cycle of the square-wave signal generated at the output of the third inverter. The period of the cycle equals six gate delays (three while the third inverter output was low and three while it was high). The frequency can be easily found if you know the period. For example, if the inverters each have a gate delay of five nanoseconds, the period of the output signal will be 30 nanoseconds, which corresponds to a frequency of 33.33 MHz. Like a dog chasing its tail, the 0s and 1s are always "circling" around the loop as fast as they can.

If we extend this concept to fiber, we have photons of light chasing each other, but there are other things to consider. Figure 2 shows the Fiber Optic Ring Oscillator circuit. In this circuit, a single inverter is used with a length of fiber optic cable. The inverter is a fiber transceiver that is wired to loop the received signal back to the transmitter, with the level inverted. So, if the fiber is initially dark, the transmitter will output light. When the light has traveled through the fiber loop and is received, the transmitter will stop emitting light. The fiber will become dark as the light empties out of it and the process will repeat.

In the ring oscillator from Figure 1, three inverters are used because the length of the wires connecting the input and output of each inverter are so short that they do not significantly affect the frequency of operation. What am I talking about? Light travels about one foot in one nanosecond. An electrical signal (electrons moving down a wire) travels slower inside copper wire. Thus, a signal that travels a foot in a copper wire requires slightly more than one nanosecond.

If we breadboard the ring oscillator using a 74LS04 hex inverter and half inch wires to connect the inverters, the total length of the wires is one and a half inches, which would correspond to less than a quarter of a nanosecond of time for the trip through the wires. This is much less than the 30 nanosecond period, so the frequency is not significantly affected by the wire length.

Light travels slower in fiber than it does in air or a vacuum. Just like the speed of the electrical signal in copper wire, the physical properties of the fiber affect the speed at which light propagates down the fiber. The fiber will have a specific velocity of propagation (VOP) depending on its physical characteristics. The 62.5/125 micrometer multimode fiber used in the oscillator has a VOP of 0.67. This indicates that the speed of light in the

Figure 2. The Fiber Optic Ring Oscillator uses a length of fiber to control the frequency of oscillation.

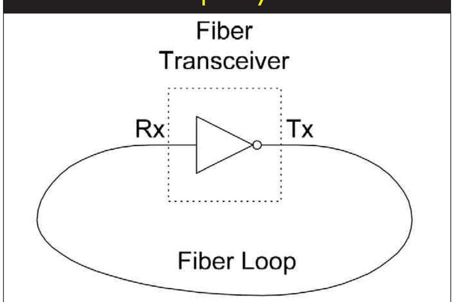
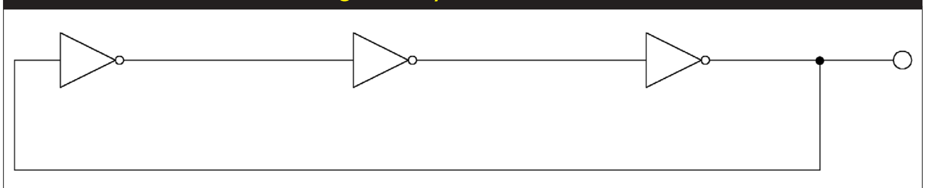


Figure 1. Three-inverter ring oscillator. Its frequency depends on the gate delay of each inverter.



fiber equals 0.67 times the speed of light (3 x 10^8 meters/sec) in a vacuum.

Now, if we make the length of the fiber significantly longer than the wire used in the three-inverter ring oscillator, the travel time through the fiber will determine the period of the oscillator, not the gate delay of the transceiver inverter. For a 100 meter length of fiber, the travel time through the fiber is calculated as follows:

Hopefully, you agree that 498 nanoseconds is significantly larger than the two to four nanosecond delay specified in the transceiver's data sheet. So, since the fiber has to fill up with light, then empty itself out for each cycle of the output signal, the period of the waveform will be twice the T_{fiber} time or 996 nanoseconds. This translates to a frequency of 1,004,016 Hz.

To appreciate what this means, consider this: the 100 meter fiber loop stretches all the way around the atrium of my campus technology building. It takes 45 seconds for me to walk a group of students around the atrium once. The light in the fiber zips around the atrium over 1,000,000 times each second. For a nine meter loop of fiber, the frequency increases to over 11 MHz.

The Fiber Optic Ring Oscillator was designed to allow students to accurately calculate the speed of light. They do this by measuring the frequency of oscillation and working backwards (knowing the VOP of the fiber) to calculate the speed of light.

The schematic for the oscillator is shown in Figure 3. It is very important to provide filter power supply voltages to the transmitter and receiver sides of the HFBR-5103 fiber transceiver. The transmitter will pull around 150 mA when it turns on, which could affect the operation of the receiver if the filtering is not adequate. In fact, when I first breadboarded the oscillator, I ignored the filter caps and inductors, driving the HFBR-5103 directly from the +5 V supply.

That was a mistake that I spent several days learning my lesson from — racking my brain, trying to understand why the circuit was oscillating faster than expected. My friend and colleague — Michael Coppola — consulted with me and explained how important it is to properly filter the power supplies.

Michael has a great deal of experience working with fiber and had already "been there, done that" with power supply filters in high speed fiber circuitry. Michael also provided a critical review of the printed circuit board designed by Don McCarty — our Electrical Engineering Technology Department Technician — who has worked with me on many electronic projects. Michael and Don discussed how thick the traces should be (signals thin, power thick) and even the placement of components on the board to minimize noise and coupling issues. Don built two oscillator boards and both worked the first time.

Figure 4 shows the circuit used to shape the oscillator output signal and divide it by 8,192 down to a frequency we can hear (123 Hz for a 100 meter fiber and 1,363 Hz for a nine meter fiber). The frequency of oscillation (Fosc) signal from the TD output of the Ring Oscillator (pin eight of the HFBR-5103) is conditioned by the 100 Ω resistor and 0.01 µF capacitor to remove the DC offset of the oscillator signal and provide a path to ground

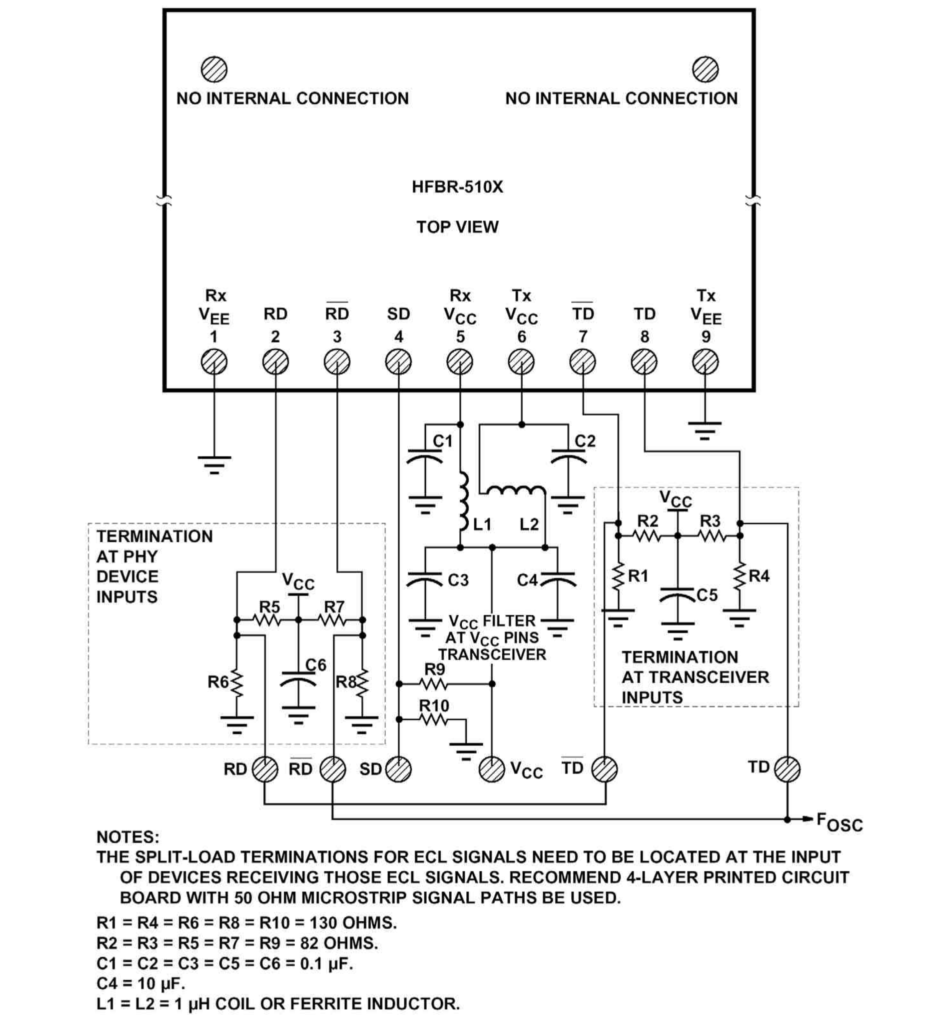


Figure 3. This is the input/output signal biasing and power supply filtering circuitry required to operate the fiber transceiver module that forms the inverter of the Fiber Optic Ring Oscillator.

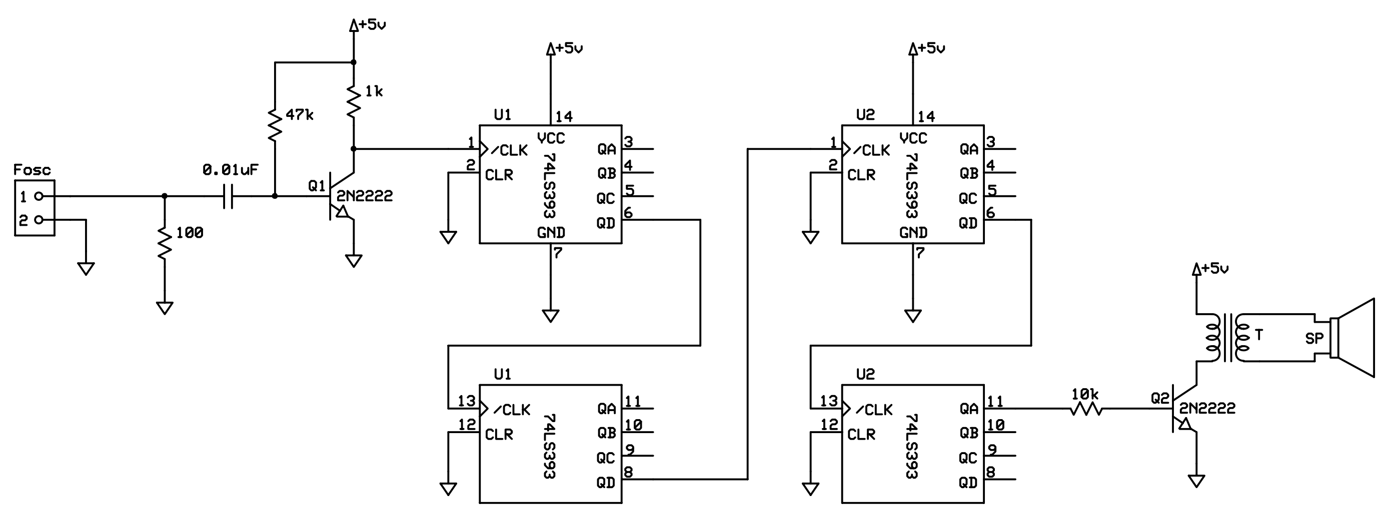


Figure 4. This digital frequency divider circuit conditions the output signal from the fiber oscillator, converts it to TTL logic levels, divides the signal frequency by 8,192, and produces an audible tone on the speaker.

for the base of transistor Q1. Q1 is base-biased by the 47K resistor so that it is always on unless something pulls the base lower than 0.7 volts.

When Q1 is on, the collector output sits at a logic zero level (essentially, all of the +5 V supply voltage drops across the 1K collector resistor). Although open for DC, the 0.01 µF capacitor acts almost like a short when operating at the high frequency rate of the ring oscillator. So, the capacitor allows the Fosc signal to yank the base of Q1 low once for each cycle.

When the base is taken low, the transistor shuts off, allowing the collector resistor to pull the output signal up to a logic one level. When the Fosc signal changes and Q1 turns on again, the output at the collector will go to a logic zero again, providing the falling edge required by the 74LS393 CLK input. The 393's are cascaded to form a 13-bit counter. Since 2^{13} equals 8,192, we need that many pulses to get a single pulse output to the speaker circuit. The audio transformer is used to provide a high impedance in the collector of Q2, so that the 8 Ω speaker does not yank on the +5 V supply too much.

So — over the course of this fiber series — we have seen that a beam of light can be used in interesting and useful ways. We should be aware of this because, right now, light is the fastest thing that we've got. Even with the Dense Wave Division Multiplexing techniques now used to place multiple 2.4 Gbps optical carriers on one fiber, we have barely tapped the communication speeds made possible with light. Perhaps we lack the necessary understanding of physics and nature to reach the full potential, but it is worth the effort to try. **NV**

About the Author

James Antonakos is a professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College. He has over 27 years of experience designing digital and analog circuitry and developing software. He is also the author of numerous textbooks on microprocessors, programming, and microcomputer systems. You may reach him at antonakos_j@sunybroome.edu or visit his website at **www.sunybroome.edu/~antonakos_j**

Micro Memories

A Phone too Far: Bell's Picturephone

Using the telephone is such a hassle these days; women have to make sure their makeup and hair is just so and all but the most Cro-Magnon of men want to appear clean-shaven and well-groomed when calling their wives or parents.

Oh, you mean you don't think about such things when you pick up the telephone? That's probably because, like 99.99% of the population, you don't own a videophone — but you would, had Bell Laboratories had their way in the early 1960s.

The Picturephone is one of those classic "what if" bits of history. It made a huge splash at the 1964 World's Fair in Queens, NY (the same one where the flying saucers were parked so they'd be ready for the first *Men in Black* movie). Two years later, Stanley Kubrick thought they would be commonplace enough in the future that, when he was shooting *2001: A Space Odyssey*, he wrote and directed a famous scene in which Dr. Heywood Floyd — one of his lead characters — called his daughter from space via a Bell Picturephone. (*2001* is full of technologies we're still waiting for. On the other hand, it's also full of brand names that are no more, such as Bell Telephone and Pan Am.)

However, as marketing experts Al Ries and Jack Trout wrote in their 1993 book, *The 22 Immutable Laws of Marketing*:

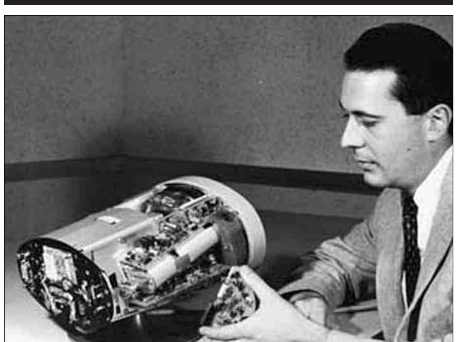
"Capturing the imagination of the public is not the same as revolutionizing a market. Take the Picturephone, now called the videophone. Ever since its introduction at the 1964 New York World's Fair, the Picturephone has been in the news, usually on the front page. The latest example is a front page story in the *Wall Street Journal,* 'The Videophone Era May Finally Be Near, Bringing Big Changes.'"

This is the third try for AT&T. In the '70s, it failed with the Picturephone, priced at $100.00 a month. In the '80s, it failed with another Picturephone, offering service at $2,300.00 an hour. In the '90s, AT&T was hustling $1,500.00 videophones. It's easy to see why the videophone hasn't made much progress. Who wants to get dressed up to make a phone call?

As a result, the idea became one of those perennial "maybe someday" ideas. The basic technology had been there since the mid-'60s to make it a reality, but it has never caught on.

1962 shot of L.H. Meacham of Bell Labs on his PicturePhone.

1962 shot of Joseph A. Mazzeo of Bell Labs removing circuits from PicturePhone.

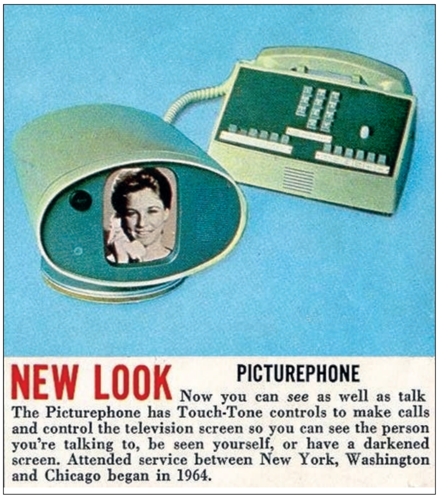


Would Have Strained Bell Network

This may have been a good thing. Had Picturephones actually caught on, they would have placed a tremendous strain on the Bell network. Each unit would have been connected to a Bell central office via three standard wire pairs, as opposed to the traditional single pair of wires that a voice-only telephone uses. One pair of wires carried the phone's 1 MHz video signal in one direction and the other carried the video in the opposite direction. The third pair carried the traditional voice information, as well as the TouchTone signals that directed each phone call.

According to the Bell System Memorial website (**www.bellsystemmemorial.com**), each central office that dealt with Picturephones had to accommodate those making Picturephone calls by adding a second switch, operating in parallel to the regular switch.

David Massey, who runs the site, writes, "The fun comes when a call has to be connected to someone served via another central office." Normally, a voice channel is allotted only 3,000 Hz (as opposed to 20,000 Hz for hi-fi audio) for each direction. A Picturephone video signal took a whopping *1,000,000 Hz*. (Maybe Austin Powers' Dr. Evil was in on their design.) "That's 333 times the bandwidth!" Massey adds, "A few video calls would fill up all available bandwidth." As a result, Massey speculates that Bell would have had



From the 1965 "The Telephone Story" poster.

to invent video data compression on the spot to have been able to handle the load.

Let the Record Show ...

Yet, the Picturephone certainly looked handsome in Bell's advertisements, in both its sleek, barrel-shaped configuration and its later, squarer shape. Massey has a scanned PDF version of the May/June 1969 issue of *Record*, a slick Bell Laboratories publication, which describes, in glowing advertising copy, the expected benefits of the Picturephone. (It's online at **www.bellsystemmemorial.com/pdf/picturephone.pdf**)

The issue begins with a gushing introduction by Julius P. Molnar, who was the executive vice president of Bell Telephone Laboratories:

"Rarely does an individual or an organization have an opportunity to create something of broad utility that will enrich the daily lives of everyone. Alexander Graham Bell, with his invention of the telephone in 1876, and the various people who subsequently developed it for general use perceived such an opportunity and exploited it for the great benefit of society. Today, there stands before us an opportunity of equal magnitude

From the 1969 "The Telephone Story" poster.

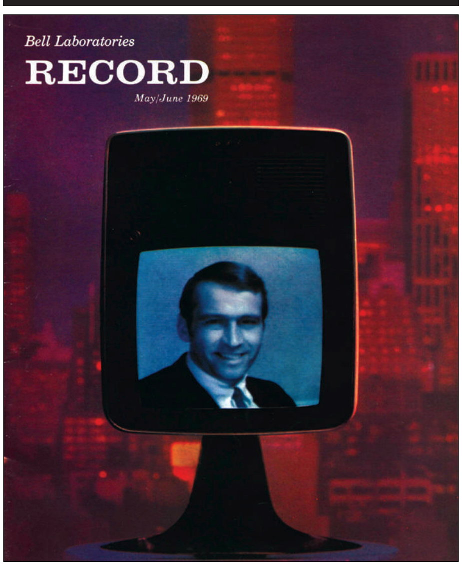
—Picturephone® service."

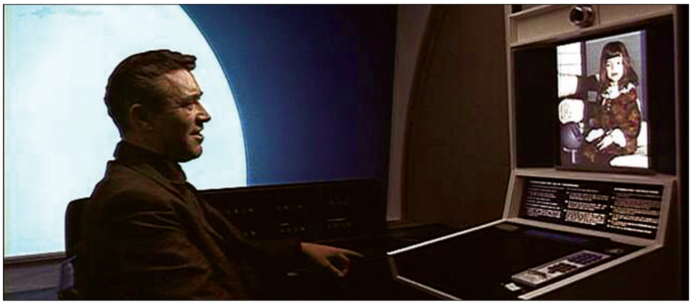
A few paragraphs later, Molnar hints at the controversy to come:

"Picturephone is, therefore, much more than just another means of communication. It may, in fact, help solve many social problems, particularly those pertaining to life in the big city. I see bringing Picturephone into general use as one of the most exciting opportunities for the wise use of modem technology.

"Most people, when first confronted with Picturephone, seem to imagine that they will use it mainly to display objects or written matter or they are very much concerned with

May-June 1969 *Bell Record* cover.

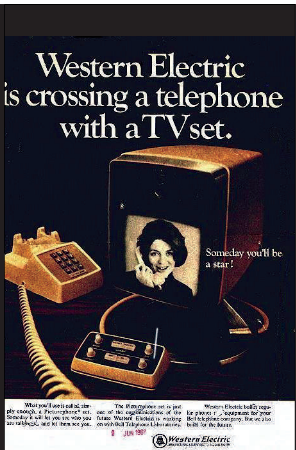




2001 predicts widespread use of the Picturephone.

2001 shows some of the fears the Picturephone raised.

how they will appear on the screen of the called party. These reactions are only natural, but they also indicate how difficult it is to predict the way people will respond to something new and different."



June 1968 Western Electric Ad.

No kidding! The Bell System estimated that 3,000,000 Picturephone units would be operating in homes and offices by the mid-1980s, bringing in a combined revenue of $5,000,000,000 a year, but the cost, both to the consumer and to the Bell network in upgrades, coupled with the simple, but extremely understandable fear by consumers of being seen at inopportune moments, soon dampened much of the enthusiasm for the project. (George Orwell's *1984* was a perennial best-seller since the late 1940s. I wonder if its two-way telescreens, used as a controlling mechanism by his futuristic, totalitarian government, also caused subliminal fears?) As a result, the project was basically DOA by the early 1970s and Bell itself died a decade later, when the Federal Government broke it into eight regional networks to diffuse its monopoly on December 31, 1983.

A New Lease on Life

In the late '90s, the concept of the Picturephone received a new lease on life via the Internet, allowing webcams to proliferate at home and enabling video meetings and teleconferencing to become commonplace in the office. Most people, though, still get dressed up at least a little bit or put on a suit and, no doubt, plan their appearance ahead of time if they know that there's a videoconference scheduled that day.

TechTV estimates that 6,000,000 webcams were sold in 2002, but how many are used regularly? Most people sit at their home computers during planned times when they surf the 'net and chat with friends, not when there's an emergency or when they need to call their spouse to pick up some milk on the way home from work. Otherwise, they're used specifically for the purpose that made Picturephones unpopular — for the "R U Nekkid" crowd and for viewing live action "pr0n."

Had the Picturephone caught on, the future would have arrived much sooner than it did for most consumers. However, that sort of speculation is a moot point; some technologies, no matter how initially appealing, just aren't meant to be. **NV**

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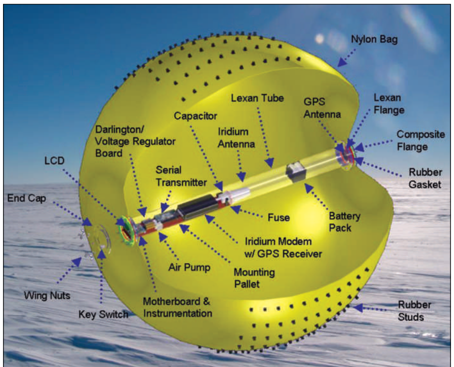
Events, Advances, and News From the Electronics World

Advanced Technologies

Simple, Cheap Rover Travels with the Wind



Exploded view of the Tumbleweed Rover, showing layout and electronics package. Courtesy of NASA Jet Propulsion Laboratory.

In any election year, it is not unusual to see bombastic bags of wind moving about the countryside. However, some of them actually perform a useful function, such as NASA's Tumbleweed Rover, which is currently under development at the Pasadena, CA Jet Propulsion Lab. Considerably less complex than the familiar Mars Rover design, this is a large, wind-blown, inflated ball that carries an instrument payload in its interior.

The Tumbleweed is designed to provide a safe and economical way of deploying instruments, such as a ground-penetrating radar and magnetometers, in a range of hostile environments. Possible utilization sites include remote areas of the Earth, as well as Mars, Venus, and Titan — perhaps even Saturn's moon Io (via supersonic volcanic wind) and Neptune's moon Triton (which shows signs of significant surface wind erosion).

One version of the rover was recently deployed in Greenland, where it completed a more than 130 km autonomous traverse across an ice sheet. Communicating via the Iridium satellite network, the rover relayed live GPS, temperature, and pressure data to a ground station at JPL every 30 minutes for nearly 10 days. At the time of this report, two more rovers were making a traverse from the South Pole to the coast of Antarctica, some 2,000 km away.

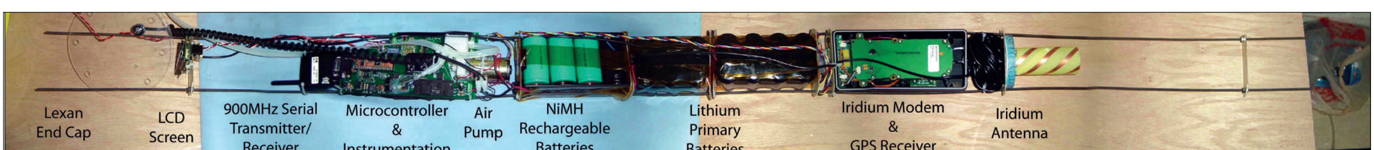
The Antarctic test is designed to obtain mapping data — in collaboration with the Antarctic Digital Database (ADD) project of the British Antarctic Survey — to demonstrate Tumbleweed's effectiveness in harvesting data in extreme and remote settings. For more information, visit **http://robotics.jpl.nasa.gov**

New Sonar Technique Screens Out Ocean Floor

Demonstrating that simpler is, indeed, often better, Dr. David M. Pierson — a physicist at North Carolina State University (**www.ncsu.edu**) — and Dr. David E. Aspnes have developed an improved method for locating objects buried in the ocean floor without the use of complex, unreliable modeling or the usual arrays of sonar transmitters and receivers. The method records the return echo of a sonar transceiver's "ping," then time-reverses and transmits that signal. The resulting echo clearly shows buried objects and suppresses the response from the seafloor itself, making the underwater terrain "transparent."

According to Pierson, using time reversal to find buried mines requires only one transceiver — although more can be used — and the method isn't limited by the composition of the ocean floor. "Previous methods had to incorporate a lot of complex modeling of the sea floor and the ocean environment and required sophisticated software and hardware systems. My time-reversal technique not only simplifies the needed equipment, but also can be implemented using existing sonar equipment, with minor software changes. More elaborate analyses of echoes are also made possible."

In a public statement, an NCSU representative noted, "The NC State discovery should please naval mine-detection experts, who now use everything from dolphins to divers to sophisticated software modeling and elaborate sonar arrays in their grim work and it should send those who design such mines back to their equally grim drawing boards."



Tumbleweed's electronics pallet. Courtesy of NASA Jet Propulsion Laboratory.

Computers and Networking

Big Power in a Small Box

The LPC-401X provides clock rates up to 3.2 GHz in a textbook-sized aluminum enclosure. Courtesy of Stealth Computer Corp.

If you need a high performance CPU, but don't have much in the way of desk space, you might want to look at the new LPC-401X from Stealth Computer Corp. (**www.stealthcomputer.com**). It's a Pentium 4-based machine that runs at 3.2 GHz, features Intel's Extreme Graphics 2 chip, and includes on-board LAN, USB 2.0, Firewire, and in/out audio processors. Included is a CD-ROM; DVD and CD/RW drives are available options. Up to 200 GB of drive space is also available. Even so, the LPC-401 measures only 10 x 5.8 x 2.8 inches (25.4 x 14.7 x 7.1 cm).

The machine is compatible with WIN2000/XP, Linux, and others. According to the company, the machine is particularly useful for deployment in applications such as digital signs, kiosks, embedded controls, human/machine interface applications, and so on. The LPC-401 is actually available in a range of configurations and you'll pay $1,095.00 for the lowly 2.0 GHz Celeron-based unit. Upgrading to the 3.2 GHz Pentium will run you another $400.00. Complete pricing details are available at the company's website; just log onto **www.stealthcomputer.com/pricelists/littlepc_p4pricelist.htm**

In Case You Smell Smoke ...

Dell, Inc., recently announced that the motherboards of all PowerEdge 1650 servers sold worldwide between January and early May of 2003 are potentially defective and should be replaced. Although there are no safety concerns, a voltage-regulating inductor can overheat, generate some smoke, and cause the machine to shut down. The machine is a rack-mount server intended for use in data centers. The company did not disclose how many servers have the problem, but will be contacting customers and making arrangements for motherboard replacements.

Hard Drive Provides Up to 300 GB Storage

The Fujitsu MAT series hard drive. Courtesy of Fujitsu, Ltd.

Fujitsu (**www.fujitsu.com**) has introduced two new series of 3.5 inch hard disk drives that deliver increased performance and storage capacity. The MAT series — featuring spindle speeds of 10,000 rpm — offers storage capacity of up to 300 GB with four-platter design. The MAU series — featuring spindle speeds of 15,000 rpm — offers up to 147 GB in storage capacity. Both are available in three capacity points, with two types of interfaces, and are designed for use in enterprise systems — from servers to storage systems. The MAT and MAU series are successors to the company's MAP and MAS series, respectively. Through improvements in areal recording density, the MAT series offers 73, 147, and 300 GB storage capacity, whereas the MAU series offers 36, 73, and 147 GB. Both are available with a choice of two interfaces — Ultra320 SCSI (U320) or Fibre Channel 2 (FC2) — and employ fluid dynamic bearing motors for quieter operation. (The motor uses viscous oil in its rotational component instead of ball bearings, increasing head positioning accuracy and reducing rotational fluctuations.)

Industry and the Profession

HP and Dell Battle

According to a report from research company IDC (**www.idc.com**), Hewlett-Packard closed out 2003 by beating its competitor — Dell (**www.dell.com**) — in fourth quarter sales. Capitalizing on holiday promotions, HP enjoyed 21% growth compared to the same quarter a year before. Dell, however, sustained growth of nearly 20% for the entire year, thus beating HP on an annual basis. The top five vendors for the final quarter were HP (7,520 units, 16.9 % market share), Dell (7,242, 16.3%), IBM (2,663, 6%), Fujitsu/Fujitsu Siemens (1,897 and 4.3%), and Toshiba (1,416 and 3.2%). All others scored sales of 23,815 units, for a total of 53.5% of the market.

"It was a good finish to a great year," said Roger Kay, vice president of client computing at IDC. "Prices attracted buyers at holiday time and vendors like eMachines and HP benefited from consumer activity in retail. Although the majors took in the richest harvest, even non-branded vendors managed to grow shares. IBM's performance was reflective of a recovering enterprise sector."

The report also observed that IBM — despite a general slide — obtained a 17% increase in sales of portable computers. Gateway shipments continued to fall "precipitously" as the company tried to reinvent itself (in part by acquiring eMachines for $280 million) and Apple Computer achieved double-digit growth in the fourth quarter, although annual sales were down slightly.

Conference Addresses Hydrogen-Based Economy

Four societies of the Institute of Electrical and Electronics

Engineers (IEEE, **www.ieee.org**) have launched the first conference to address the technologies and impact of a hydrogen-based economy. Titled "The Hydrogen Economy: Its Impact on the Future of Electric Energy," the conference was held in Washington, DC, late in April. Organized by the Power Engineering Society, Power Electronics Society, Industry Applications Society, and the Society for Social Implications of Technology, the conference focused on information about what a hydrogen-based economy would look like, what the technologies are, and what impact it would have on our society. A slate of technical experts offered focus on hydrogen production, its delivery infrastructure, power generation technologies, system interface issues, and case studies from North America, Europe, and Japan; the potential impact of hydrogen fuel on the future delivery of electric energy was also discussed.

In its mission statement, the group noted, "The IEEE is a leading authority in a wide range of technical areas — including electric power — and is organizing this conference to provide a venue for furthering the participants' knowledge base on hydrogen systems. We hope this will help to develop relationships with the hydrogen energy industry as the US and many other industrialized nations move forward towards a hydrogen economy." If you are interested in upcoming events, visit **www.energetics.com/hydrogen**

Circuits and Devices

New Audio Amplifiers for Home Stereo Systems

National's LM478x audio amplifiers feature fade-in/fade-out mute mode circuitry. Courtesy of National Semiconductor Corp.

National Semiconductor Corp. (**www.national.com**) has introduced three new stereo audio amplifiers in its Overture® line of products for home stereo systems. The devices feature quiet fade-in/fade-out mute mode circuitry that gradually brings the sound up or down, which is intended to enhance the listening experience in compact stereos, high-definition televisions (HDTVs), 5.1 surround sound systems, and other consumer electronic equipment. The LM4780 is a stereo audio amplifier capable of delivering 60 W per channel of continuous average output power. The LM4781 is a three-channel audio amplifier capable of delivering 35 W per channel of continuous average output power into an 8 Ω load and the LM4782 is a three-channel audio amplifier capable of delivering 25 W per channel of continuous average output power into an 8 Ω load. All three devices are specified at less than 0.5% total harmonic distortion plus noise (THD+N) from 20 Hz to 20 kHz.

The chips are protected by National's self-peak instantaneous temperature (°Ke) (SPiKe) protection circuitry, which provides a dynamically optimized safe operating area. SPiKe protection safeguards the device outputs against overvoltage, undervoltage, overloads, shorts to the supply or ground, thermal runaway, and instantaneous temperature peaks.

The LM4780/81/82 audio amplifiers can easily be configured for bridge or parallel operation for higher power and bi-amp solutions. In addition, the LM4782 has a power-conserving stand-by mode. The 4780/81/82 devices — in TO-220 packaging — are respectively priced at only $3.25, $3.25, and $2.75 in lots of 1,000, so your next stereo system may be highly affordable. **NV**

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Professional FM Stereo Radio Station

✔ **Synthesized 88-108 MHz with no drift**
✔ **Built-in mixer - 2 line inputs, 1 mic input**
✔ **Line level monitor output**
✔ **High power version available for export use**

The all new design of our very popular FM100! Designed new from the ground up, including SMT technology for the best performance ever! Frequency synthesized PLL assures drift-free operation with simple front panel frequency selection. Built-in audio mixer features LED bargraph meters to make setting audio a breeze. The kit includes metal case, whip antenna and built-in 110 volt AC power supply.

FM100B	**Super-Pro FM Stereo Radio Station Kit**	**$269.95**
FM100BEX	**1 Watt, Export Version, Kit**	**$349.95**
FM100BWT	**1 Watt, Export Version, Wired & Tested**	**$429.95**

Professional 40 Watt Power Amplifier

✔ **Frequency range 87.5 to 108 MHz**
✔ **Variable 1 to 40 watt power output**
✔ **Selectable 1W or 5W drive**

At last, the number one requested new product is here! The PA100 is a professional quality FM power amplifier with 30-40 watts output that has variable drive capabilities. With a mere one watt drive you can boost your output up to 30 watts! And this is continuously variable throughout the full range! If you are currently using an FM transmitter that provides more than one watt RF output, no problem! The drive input is selectable for one or five watts to achieve the full rated output! Features a multifunction LED display to show you output power, input drive, VSWR, temperature, and fault conditions. The built-in microprocessor provides AUTOMATIC protection for VSWR, over-drive, and over-temperature. The built-in fan provides a cool 24/7 continuous duty cycle to keep your station on the air!

PA100	**40 Watt FM Power Amplifier, Assembled & Tested**	**$599.95**

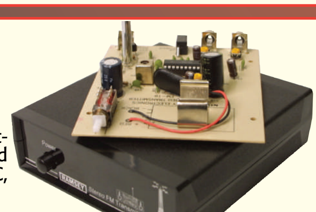
Synthesized Stereo FM Transmitter

✔ **Fully synthesized 88-108 MHz for no drift**
✔ **Line level inputs and output**
✔ **All new design, using SMT technology**

Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer! A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's 'digital' receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, and easy assembly instructions - you'll be on the air in just an evening!

FM25B	**Professional Synthesized FM Stereo Transmitter Kit**	**$139.95**

Tunable FM Stereo Transmitter

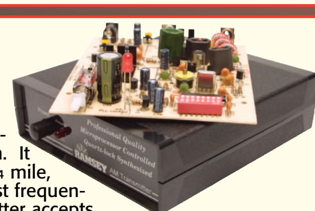


✔ **Tunable throughout the FM band, 88-108 MHz**
✔ **Settable pre-emphasis 50 or 75 µSec for worldwide operation**
✔ **Line level inputs with RCA connectors**

The FM10A has plenty of power and our manual goes into great detail outlining all the aspects of antennas, transmitting range and the FCC rules and regulations. Runs on internal 9V battery, external power from 5 to 15 VDC, or an optional 120 VAC adapter is also available. Includes matching case!

FM10C	**Tunable FM Stereo Transmitter Kit**	**$44.95**
FMAC	**110VAC Power Supply for FM10A**	**$9.95**

Professional Synthesized AM Transmitter



✔ **Fully frequency synthesized, no frequency drift!**
✔ **Ideal for schools**
✔ **Microprocessor controlled**

Run your own radio station! The AM25 operates anywhere within the standard AM broadcast band, and is easily set to any clear channel in your area. It is widely used by schools - standard output is 100 mW, with range up to ¼ mile, but is jumper settable for higher output where regulations allow. Broadcast frequency is easily set with dip-switches and is stable without drifting. The transmitter accepts line level input from CD players, tape decks, etc. Includes matching case & knob set and AC power supply!

AM25	**Professional Synthesized AM Transmitter Kit**	**$99.95**

Tunable AM Transmitter

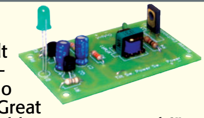
✔ **Tunes the entire 550-1600 KHz AM band**
✔ **100 mW output, operates on 9-12 VDC**
✔ **Line level input with RCA connector**

A great first kit, and a really neat AM transmitter! Tunable throughout the entire AM broadcast band. 100 mW output for great range! One of the most popular kits for schools and scouts! Includes matching case for a finished look!

AM1C	**Tunable AM Radio Transmitter Kit**	**$34.95**
AC125	**110VAC Power Supply for AM1**	**$9.95**

Mini-Kits... The Building Blocks!

Tickle-Stick



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC

TS4	**Tickle Stick Kit**	**$12.95**

Super Snoop Amplifier

Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC

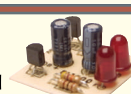
BN9	**Super Snoop Amp Kit**	**$9.95**

Dripping Faucet

Produces a very pleasant, but obnoxious, repetitive "plink, plink" sound! Learn how a simple transistor oscillator and a 555 timer can make such a sound! Runs on 4-9 VDC.

EDF1	**Dripping Faucet Kit**	**$9.95**

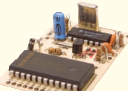
LED Blinky



Our #1 Mini-Kit for 31 years! Alternately flashes two jumbo red LED's. Great for signs, name badges, model railroading, and more. Runs on 3-15 VDC.

BL1	**LED Blinky Kit**	**$7.95**

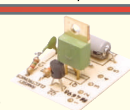
Touch Tone Decoder



Strappable to detect any single DTMF digit. Provides a closure to ground up to 20mA. Connect to any speaker, detector or even a phone line. Runs on 5 VDC.

TT7	**DTMF Decoder Kit**	**$24.95**

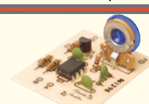
Electronic Siren



Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.

SM3	**Electronic Siren Kit**	**$7.95**

Universal Timer



Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.

UT5	**Universal Timer Kit**	**$9.95**

Voice Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.

VS1	**Voice Switch Kit**	**$9.95**

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.

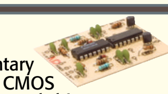
TD1	**Encoder/Decoder Kit**	**$9.95**

RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7	**RF Preamp Kit**	**$19.95**

Touch Switch



Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.

TS1	**Touch Switch Kit**	**$9.95**

Basics For Beginners

Just For Starters

Reading Schematic Diagrams

People communicate their ideas via written text, yet it is true that a picture is worth a thousand words. Electrical circuits are commonly documented in graphical form to describe their specific components and connections. These pictorial representations are termed "schematic diagrams" because they explain functionality rather than serving as a photograph of a circuit board. Reading and interpreting schematic diagrams is an important skill for anyone who wants to work with electronic circuits.

There is no single set of rules governing how schematic diagrams are created. There are almost as many styles as there are engineers. A common stylistic difference is how each type of component (e.g., resistor or transistor) is drawn. Fortunately, schematic diagrams tend to share many common attributes.

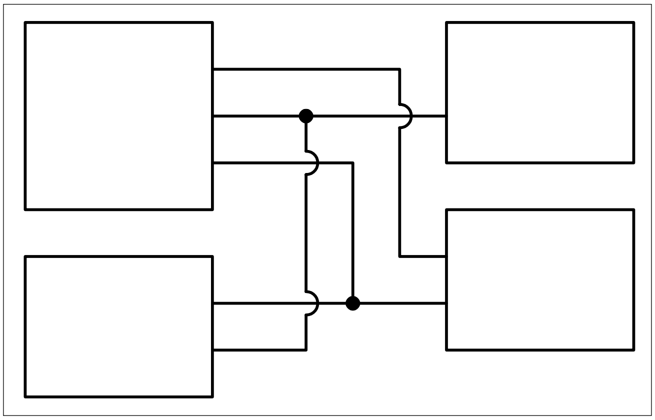
Once you've learned the basics and have seen a few different styles, you can usually decipher a new style with relative ease. Every so often, however, we all come across a mystery. Unraveling that mystery may be done by its context or through descriptive text that may accompany the schematic diagram. This article provides a quick overview of how schematic diagrams are commonly drawn.

Wires

Wires are a basic element of schematic diagrams — they attach to and connect every electrical component. A wire is usually drawn as a straight line with neat 45° or 90° bends. Some diagrams may have curved wires, but many curved wires can start to look like spaghetti very quickly. Figure 1 shows a variety of wire representations connecting generic components that are represented as rectangles.

A small, filled circle or dot indicates a connection between two intersecting wires. Intersecting wires without a dot do not have an electrical connection. Small intersection dots and poor printing/scanning processes can lead to confusion as to whether or not intersecting wires are really meant to connect. Some schematic diagrams clarify this by placing a "bump" at the intersection of two non-connecting wires.

Figure 1. Wire Representations.

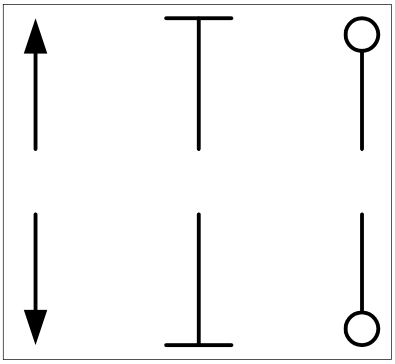


Power and Ground

Electrical circuits require power to operate and each schematic diagram shows how its components are powered. There are many styles for representing power nodes, some of which are shown in Figure 2. Arrows are most common and they point up or down, depending on whether the voltage level is positive or negative. Tee and inverted-tee symbols are sometimes used in place of arrows. Some people may draw circles. Regardless of the symbol used, power nodes are often labeled with their voltage (e.g., +5 V, -12 V, etc.) or with a variable (e.g., +V, $-V_{POWER}$, etc.).

Explicit ground nodes are found in most electrical circuits, although some circuits may refer to ground as a variable, such as GND. Ground nodes are drawn in varying styles, but almost always point downward with multiple small lines, as shown in Figure 3. Some circuits contain multiple ground nodes (e.g., earth and signal ground) and each ground is distinguished by using a different symbol. There is no universal standard (though there are standards in

Figure 2. Power Nodes.



certain industries) for what symbol represents each type of ground, so you usually must determine that from context.

Resistors

Perhaps the most common electrical component is the resistor, which is found in practically every circuit. Resistors are so simple and ubiquitous that they are almost always represented as a series of zig-zag lines. Figure 4 illustrates resistors accompanied by various attributes, such as resistance (in Ω), tolerance, and power rating. Schematic diagrams do not usually specify every possible attribute of each resistor. An organization may have a default set of attributes for all resistors (e.g., 5% tolerance, 0.1 W, 0603 package). Therefore, only each resistor's value (e.g., 10 Ω) must be included in the diagram. Exceptions to the default attributes, such as a resistor with a higher power rating, can be noted in the schematic diagram as text next to the appropriate resistors.

Each unique component in a schematic diagram typically contains a unique reference designator, which is simply a unique identifying label. Resistors take the form "Rx," where "x" increments from one up to whatever number of resistors are in the design.

Capacitors

The capacitor is another ubiquitous component in most circuits. Capacitor representations generally reflect the basic structure of a capacitor: two metallic "plates" separated by an insulating dielectric. Capacitance is measured in Farads and capacitors also have voltage ratings, which are sometimes specified in the schematic diagram. Figure 5 shows various capacitor symbols, each of which has a "Cx" reference designator. Capacitors may be polarized or non-polarized. A polarized capacitor is indicated by either placing a "+" near the positive lead, curving the negative plate, or both. As with resistors,

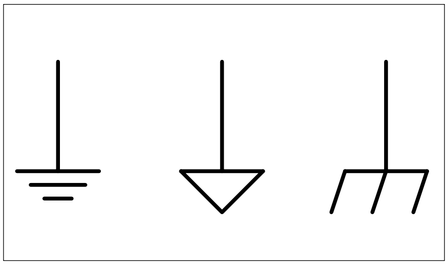


Figure 3. Ground Nodes.

capacitor attributes are explicitly mentioned as necessary.

Switches

Many projects include switches or push buttons to control the circuit's behavior. Like many other symbols, switches and buttons are drawn to represent what they actually do: make and break electrical contact between two or more terminals. Figure 6 shows several styles of switches and push buttons that use "SWx" as the reference designator format. Common switch configurations include SPST (single-pole-single-throw) and DPDT (double-pole-double-throw). Buttons can be drawn in either N.O. (normally open) or N.C.

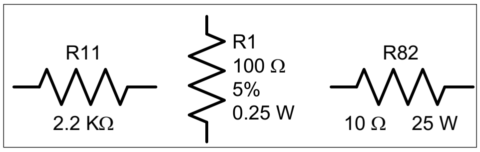


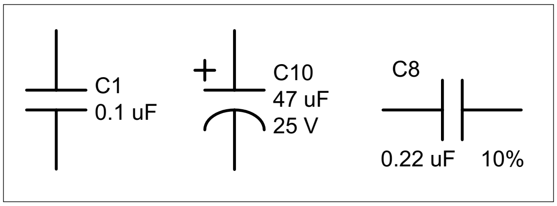
Figure 4. Resistors.

(normally closed) configurations. How a switch or button is drawn depends on the operation of the physical component. As such, you will encounter new variations from time to time.

Diodes and Transistors

Discrete semiconductor components, such as diodes and transistors, are found in many circuits. There are several basic types of diodes and transistors, but there are many specialized variants, each with its own symbol. Figure 7 shows the basic

Figure 5. Capacitors.



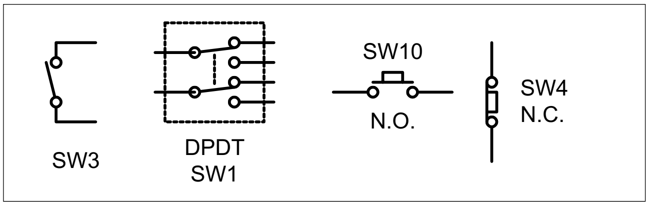


Figure 6. Switches and Push Buttons.

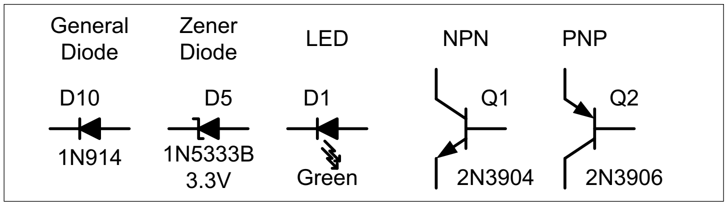
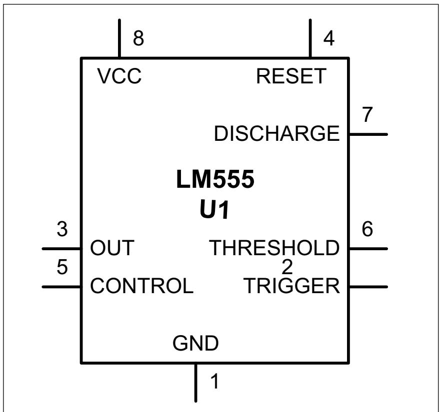


Figure 7. Diodes and Transistors.

symbols for a small-signal diode, an LED (light emitting diode), a Zener diode, and NPN and PNP transistors. As with other components, electrical ratings (e.g., power, voltage, current) may be included in the diagram.

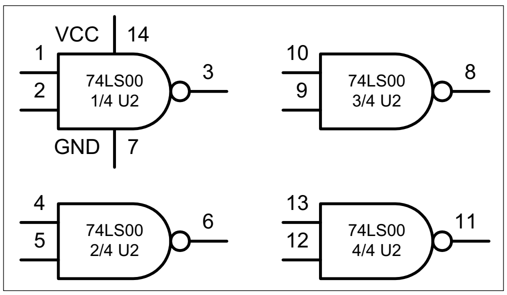
Diodes and transistors use "Dx" and "Qx" reference designators,

Figure 8. LM555 Symbol.



respectively. Symbols often include detailed part information — such as the component part number — because there are wide ranging characteristics between different diodes and transistors. Understanding the function of a diode, transistor, or semiconductor in general goes beyond the basic skill of reading a schematic diagram. You need familiarity with the component and how it behaves in various configurations.

Figure 9. 74LS00 Break Out.



Integrated Circuits

Schematic representation styles for ICs are quite numerous due to the great diversity among ICs. General ICs are drawn as a rectangle with multiple pins on one or more sides. Each pin has both a signal name and a pin number. Figure 8 shows a symbol for an LM555 timer IC. Simple logic ICs may break out individual gates for clarity, as shown in Figure 9.

Note that the 74LS00's power pins (V_{CC} and GND) are drawn on the first of four NAND gates that comprise the IC. Like other components, each IC in a schematic diagram has an associated reference designator. IC reference designators are generally in the format "Ux."

It's Just Documentation

Keep in mind that schematics are just another form of documentation and, therefore, styles vary according to the context and intent of the designer. While certain institutions may have standards, there are no universal rules for how to draw a schematic diagram. The main goal to keep in mind when drawing a schematic diagram is clarity.

Feel free to insert descriptive text or sketch a picture to convey accurate information to your intended audience.

There is a vast collection of electrical components in the world and each item's symbol may look a little different from others. Therefore, you learn to read schematic diagrams by diving into a particular circuit and trying to figure it out. You'll gain "schematic literacy" after doing this a few times. **NV**

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Skynet	SNP-0502-B	+5V@0-2A	**184866MC**	**$13.49**
Artesyn	NLP25-7608	+5V@0.2-2A; +12V@0.1-0.8A; -12V@0-0.1A	**218501MC**	**39.95**
Mean Well	PS-65-24	+24V@0-2.7A	**148646MC**	**33.95**
Artesyn	NLP150L-96Q5366	+3.3V@0.5+10A; +5.1V@1.5-2.0A; +12V@0-2A;+12V@0-0.65A	**219029MC**	**116.85**
Digital Power	USS250-115	+15V@0-16.5A	**204564MC**	**49.95**

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123246MC

Mfr.	Mfr. Cross Reference No.	Output Rating (Volts@Current)	Input (VAC@Hz)	Jameco Part No.	Price
Mean Well	S-25-5	+5V@0-5A	85-264@47-63	**123246MC**	**$43.95**
Mean Well	S-60-24	+24V@0-2.5A	85-264@47-63	**123351MC**	**57.95**
Mean Well	S-150-24	+24V@0-6.5A	88-132/176-264@47-63	**123449MC**	**76.95**
Mean Well	SP-300-24	+24V@0-12.5A	88-264@47-63	**137402MC**	**185.95**
Power-One	PFC-500-1024	+24V@0.6-21A	85-264@47-63	**202905MC**	**69.95**

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DCR1205F12	+12@500mA	3.2 x 2.2 x 1.9	—	**162996MC**	**8.95**
DC1205F5	+12@500mA	2.5 x 2.1 x 1.7	UL/CSA	**102277MC**	**4.95**
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SPU50-3	60	+12@5.0A	100-240@47-63	5.6 x 2.9 x 1.5	**155230MC**	**49.95**
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Sunon	KD1208PTB1-6	12	42.5	33.5	3.15 x 3.15 x 1.00	**102955MC**	**$5.25**
NMB	3110KL-04W-B10	12	25	25	3.15 x 3.15 x 1.00	**131748MC**	**7.95**
Sunon	KD1204PFB2-8	12	6.3	30	1.60 x 1.60 x 0.40	**161699MC**	**7.95**
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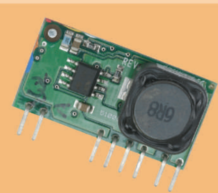

219150MC

Mfr.	Mfr. Cross Reference No.	Power (W)	Output Rating (Volts@Current)	Input Range	Jameco Part No.	Price
Mean Well	SCW03A-05	3.0	+5V@600mA	9-18V	**213268MC**	**$15.49**
Mean Well	SD-25A-24	26.4	+24@1100mA	9-18V	**175812MC**	**40.95**
Mean Well	SKE15A-05	15.0	+5V@3000mA	9-18V	**155715MC**	**34.95**
Artesyn	SIL06C-05SADJ-V	20.0	+0.9-3.3V@6	4.5-5.5V	**219150MC**	**12.35**
Astec	AA9090A	21.0	+5.1V@3750mA; +12.6V@100mA; -26V@40mA	0-20V	**109276MC**	**6.95**

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Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at: **TJBYERS@aol.com**.

What's Up:

Zero-crossing applications, o'scope software, and a 555 timer calculator.

A bunch of timers: 24-volt commercial grade, precision on/off, and a weekly timer.

A guitar preamp and electronic push button on/off switch.

Zero-Crossing Detectors

Q. I found your October 2003 article on zero-crossing detectors ("Another Zero-Crossing Detector") very interesting. However, I do not know much about these detectors. Please provide me with a few practical applications.

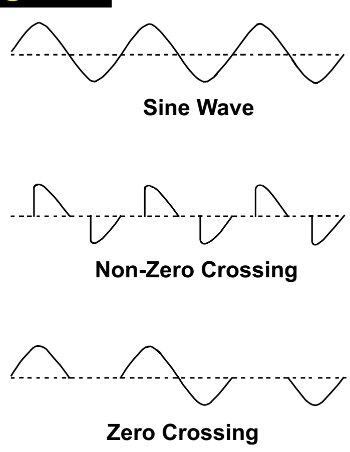
Joel Smith
via Internet

A. Here are a few applications where zero-crossing detectors are used.

1. Video blanking signals for blanking the screen during the retrace of a raster.
2. Breaker-less ignition systems.
3. Microcontroller sensor position /speed interface.
4. Phase and frequency measurements.
5. Speech/music discriminators in digital recordings.

The most prolific use of zero-crossing is for the switching of power circuits. Let's take the typical lamp dimmer as an example. Cheap lamp dimmers simply chop up the sine wave to adjust the brightness of the lamp. They do this by detecting the zero-crossing of the waveform and waiting a specified time before turning on the conducting switch — typically a triac or SCR. (Figure 1) However, this method generates vast amounts of RFI that can cause noise and interference in electronic devices. A better solution is to turn on the switch only at the zero-crossing point.

Figure 1



While I used a light dimmer for the example of zero-crossing, they have far-reaching power switching applications, including industrial motors and solenoids. In addition to reducing RFI emissions, zero-crossing switching provides a "soft-start" that eliminates surge currents.

Guitar Preamp

Q. I read the microphone preamp answer in the December 2003 issue and I was wondering if this same preamp would work for an acoustic guitar that has a pickup in it?

Walter
via Internet

A. Nope. The amp is designed for a very small input voltage in the range of 2 mV to 10 mV. The output of a high performance guitar pickup can be as much as 2.5 volts when you start rockin'. The best guitar preamp circuit I've found to date was designed by J. Donald Tillman way back in 1993 and uses a single FET transistor. You can download it from his website (**www.till.com/articles/index.html**) or find it here in Figure 2.

Unlike the design in the December issue, the gain of this preamp is just 3 dB (double the input voltage) and acts more like an impedance converter than an amplifier.

This circuit changes the impedance of the guitar pickup from 1 MΩ to 51 KΩ, which, in turn, reduces the amount of noise picked up by the connecting cable. It also reduces the attenuation of the higher frequencies (roll-off) at low volume.

That's not to say you can't add a high-frequency boost to your sounds (to give it that Jimmy Hendrix effect). Simply insert the optional C1. The FET is a low-noise J201 (Vishay) which is available from Mouser Electronics (800-346-6873; **www.mouser.com**), but a 2N5457 will work as well and is more readily available.

BTW, I added this preamp (which I built into the guitar cord) to my Gibson Pearl and it improved the signal-to-noise ratio (SNR) by a full magnitude — i.e., much less hum.

Breathless in Seattle

Q. I'm looking for a diagram which would act as an on/off switch by detecting air movement. In other words, it would turn on whenever it detects air movement and turn off when not detecting air movement. The switch has to be sensitive enough to react to a desktop fan or the air movement which occurs when a door is opened.

Anonymous
via Internet

A. For this kind of sensitivity, I suggest using thermistors to detect air movement. Thermistors have long been used to monitor gases of all sorts because they react quickly to changing temperatures. Basically, a thermistor is a temperature-sensitive resistor of which there are two types: those that increase resistance as the temperature rises (PTC) and those that decrease in resistance as the temperature rises (NTC). For this project, we use NTC (Negative Temperature Coefficient) thermistors.

A characteristic of the NTC thermistor is that, when you pass current through it, it dissipates power — heat. This causes the resistance to decrease, which allows more current to flow, which results in more heating. At some point, the amount of self-heating equalizes the heat dissipated to free space (air).

Herein lies the principle of air flow detection. Different gases — helium and nitrogen, for example — dissipate heat at different rates, which can be measured via thermistors. When you add air flow (chill factor), the cooling rate is even more pronounced. That is the heart of this sensor.

R1 and R2 in the schematic (Figure 3) represent the two NTC thermistors in this design. One thermistor (R2) is sealed inside a windproof cage that has access to outside ambient air. My favorite shield is an upside-down prescription bottle with an open bottom and a couple of small holes drilled at the top for ventilation. This allows R2 to heat the air around it for a reference. R1 is also subjected to the self-heating effect, but, this time, it's exposed to ambient air — including cooling via air currents.

The first stage uses the LM324 op amp to establish a virtual ground. The next section is an amplifier that sets the sensitivity via Rf. Using a 10K resistor, the gain is about 10. The output of this stage goes to a comparator, which closes the reed relay when air flow is detected by R1. The trigger potentiometer adjusts the trip point.

Making this circuit work will take some effort on your part. That is, you have to increase or decrease the value of Rf to get the sensitivity you desire, which, in turn, causes readjustment of the trigger pot.

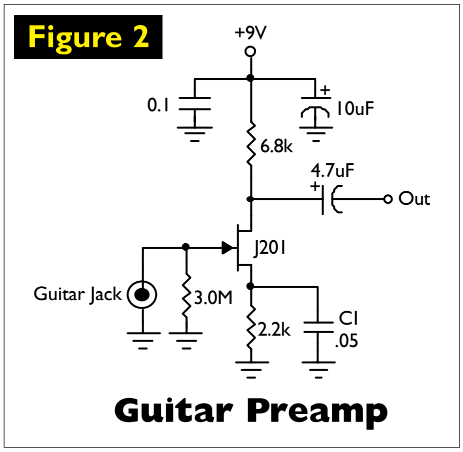


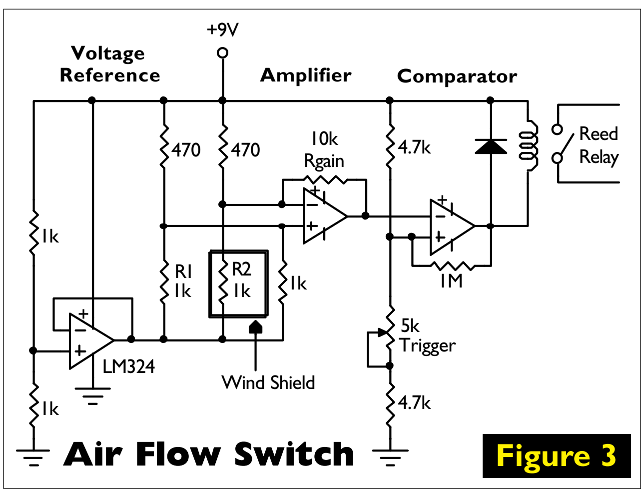
Figure 2
Guitar Preamp

Commercial Grade Delay Timer

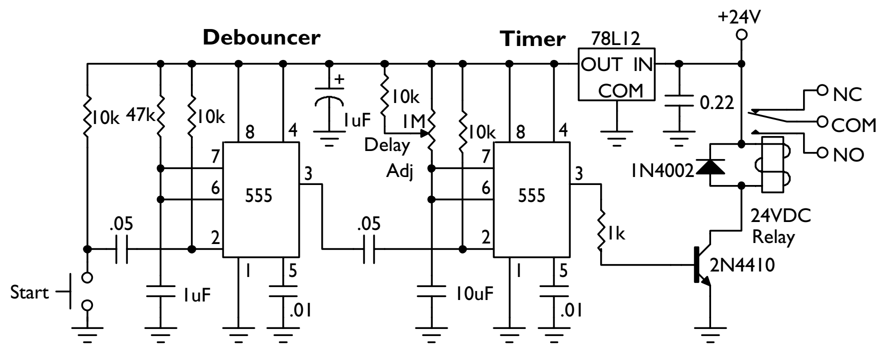
Q. I am trying to buy some delay timers, but the supplier has been extremely slow. The timers I am most interested in are for a 24-volt, DC relay circuit. I can purchase the relays from RadioShack faster and incorporate a 555 or 556 timer, but I am not sure how to put the two together. Presently, I am working on a piece of equipment that requires a variable 0.1 to 10 second delay. Can you give me a link to designs for such timers?

Larry Fostano
via Internet

A. The kind of industrial timer you request is probably best done using a pair of 555 ICs or a single 556. You'll also need a regulator, a 24-volt relay, and a transistor driver. The first 555 (Figure 4) is used to debounce the start switch and trigger the delay timer via a negative-going pulse on pin 2. This causes pin 3 to go high, turn on the transistor, and engage the relay for the time specified (via the 1 M Delay Adj.). The values have been selected for a range of 0.1 to 10 seconds. Other values of the 10 µF timing capacitor will reduce or



Air Flow Switch
Figure 3



0.1 - 10 Sec Delay Relay

Figure 4

increase that range. I could give you a formula for calculating the time delay, but I'll give you a 555 calculator instead. My favorite is 555_CALC.zip, which you can find posted on our website (**www.nutsvolts.com**). Here are some additional 555 websites that sport 555 timer calculators.

www.meridianelectronics.ca/gadgets/555/555.html

www.talkingelectronics.com/FreeProjects/555/555-P3.html

http://freespace.virgin.net/matt.waite/resource/handy/pinouts/555/

Precision On/Off Timer

Q. I have been looking for a circuit to turn a relay on for 15 minutes and off for 15 minutes, continuing in this pattern until I turn it off. It has to be accurate and needs to operate from a 9-volt DC source. Can you help me on this?

Robert Hernandez
via Internet

A. The fact that you need a precision timer normally translates into an expensive digital divider solution — one that requires a crystal oscillator running at no less than 32 kHz divided down to 15 minute increments. That takes 25 flip-flops plus support circuitry for fractional division and a regulated power supply.

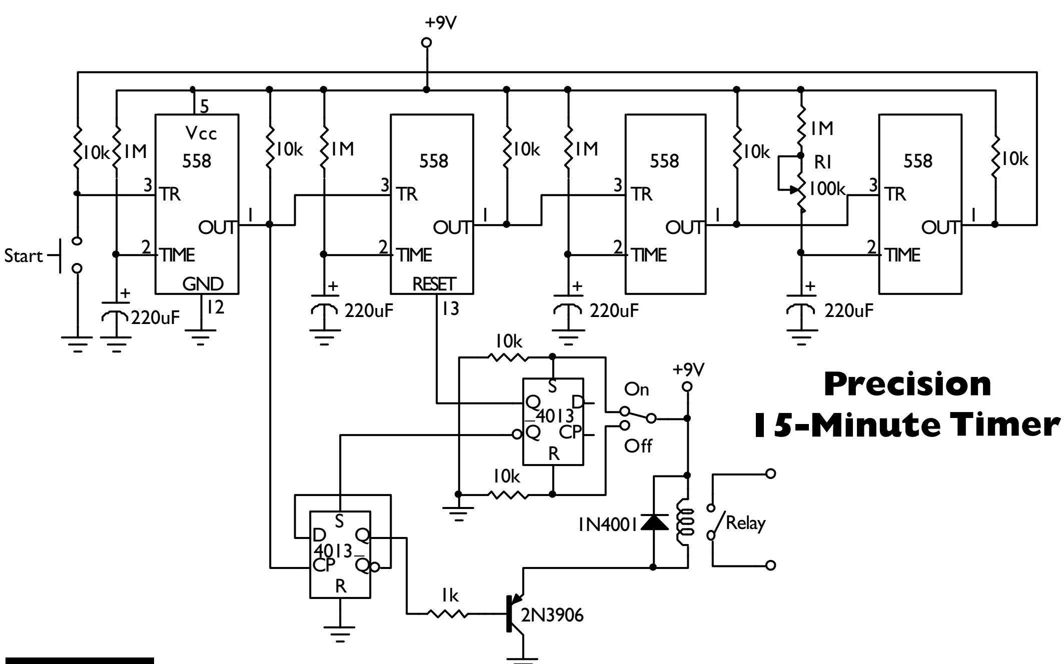
However, a reasonably accurate timer can be made using a 558 ring counter and a pair of D-type flip-flops (Figure 5) — just two ICs and a fistful of resistors and capacitors. A ring counter is a concatenated string of monostable multivibrators where the output of the last stage feeds back and triggers the first stage so that the ripple effect never stops. The 558 contains four monostable stages.

If each stage times out at exactly 225 seconds, the total time delay from start to finish is 15 minutes. Using standard values of 1 MΩ and 220 µF, the time delay is 220 seconds, which is an overall error of 20 seconds. R1 is used to adjust the final stage to make up for this difference and normal variations (tolerance) in the timing components.

The 4013 flip-flop is used to toggle the relay between on and off, thus assuring a precise 50% duty cycle. The spare flip-flop is used as a logic switch for the ring's operation. With S1 in the OFF position, both chips are reset and armed. Moving S1 to ON and pressing the Start button starts the timer.

Different delay times can be done by changing the value of the timing capacitors (220 µF) and/or timing resistors (1 M).

The 558 chip isn't as popular as it used to be, so you'll have to search for it under names like NE558 and SE558 or the very expensive NTE926. At the time of this writing, Jameco (800-831-4242; **www.jameco.com**) had the NE558 in stock at just $.69.



Precision 15-Minute Timer

Figure 5

PC O'scope

Q. In "Capacitor ESR Tester," in the January 2004 issue, you mentioned, "a converted PC sound card oscilloscope." How do you create a PC sound card o'scope?

Warren
Chas, SC

A. With software. There are several packages to choose from — most of them free. My favorite is Winscope, which you can download from our website (**www.nutsvolts.com**) under the filename WINSCOPE.ZIP. This dual-trace oscilloscope is made by converting the audio signals of the left and right inputs of the sound card into digital numbers using the card's onboard ADC. The upper frequency response is limited to just 20 kHz, but that's sufficient for most audio work and experimentation.

Downloadable Data Sheets

Q. I am searching for a website to look up data sheets. For example, I would type 74LS00 and the site would show the actual data sheets for this device. Does such a site exist?

Sassan
via Internet

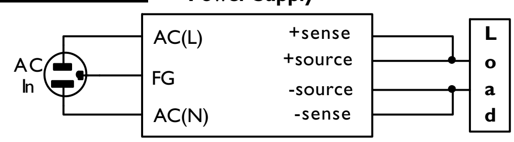
A. There are a couple of Internet websites that provide a data sheet service like you describe, but I usually go to the horse's mouth first — the chip vendors. If I don't know the vendor's website address, I can find it at **www.datasheetlocator.com** When it comes to obsolete or obscure data sheets, I've had very good luck with **www.datasheetcatalog.com** Beyond that, there are pay-per-download services, like **www.chipdocs.com**

Standard Power Supply Designations

Q. I bought a power supply from an eBay auction that I want to use for some projects. The supply is a K150AU-24, made by Cosel. A net search turned up nothing on specs. I need to know what some of the markings on the back are. The screw terminals from left to right read: +V+S, +V, -V, -V-S, FG, AC(L), and AC(N). Can you help me?

Brian Gracia
via Internet

Figure 6



Remote Sensing Power Supply

A. Here are the definitions of the terminals.

The remote sense terminals are the voltage regulator inputs and have to be tied to their respective source terminal. Normally, this connection is made inside the power supply. By separating them and making them available from the outside, you can compensate for voltage loss in the wiring between the power supply and the load. Let me illustrate by the way of a drawing (Figure 6).

Cell Phone to PC Card Interface

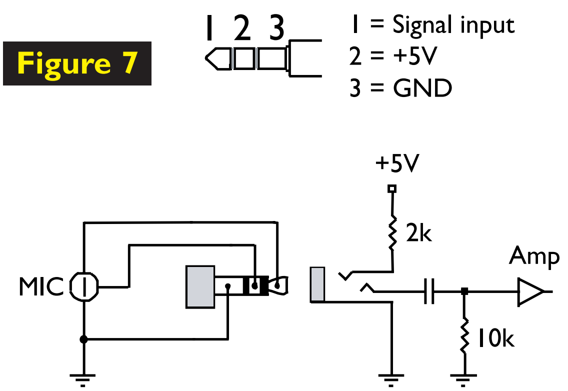
Q. I have been interested in interfacing a standard cell phone hands-free headset to my laptop via the Mic and Spkr jacks. I have succeeded in getting the speaker output to play through the headset earpiece, but I have been unable to make the microphone feed audio into the laptop. As I understand it, the impedance is identical, so I must be missing something.

Miguel Chabolla
via Internet

A. Most cell phone headset microphones use a 2.5 mm plug, whereas the PC card uses a 3.5 mm jack. This means that, if the headset plug fits into the sound card, it probably isn't compatible with either standard cell phones or PCs.

The microphone (Mic) input of a PC sound card requires about 1 volt of audio, which requires an amplified electret microphone — which, in turn, requires a power supply. This power is provided through the center contact of the microphone plug (Figure 7). The power supply is severely

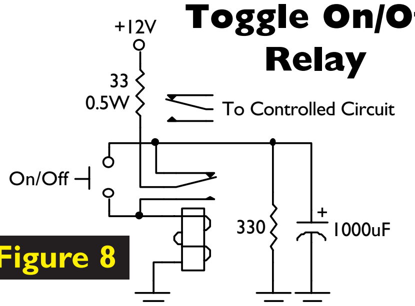
Figure 7



Sound Card Microphone Input

current-limited via the 2K resistor so that plugging in a standard (non-segmented) plug won't short out the power source. Although the sound card Mic voltage is spec'ed at 5 volts, it's often any voltage between 3 and 5 volts.

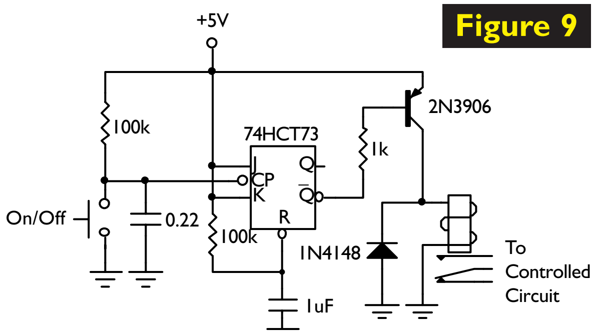
Now, if you can fabricate an adapter cable that matches the plug of the PC sound card to that of your headset, you will have a working system.



Toggle On/Off Relay

Figure 8

Figure 9



Toggle On/Off Relay

Push On/Off Switch

Q. I need a simple circuit to turn a relay on and off with a momentary push button. It needs to turn the relay on with one push and off with another push. The system it controls will be operating at 12 volts. The push button is part of a decorative piece and cannot be replaced with any other buttons or switches without severely detracting from the aesthetics, so replacing it with a push on/off mechanical button is not an option.

Ray
via Internet

A. Let me look into my magic bag of tricks. Ah, here are two circuits that should fill the bill.

The first (Figure 8) uses a DPDT relay that uses one set of contacts for the on/off function and the other set to control your load. When power is first applied, the 1,000 µF capacitor charges through the 33 Ω resistor. Full charge is reached in about 150 mS. When the push button switch is pressed (closed), the cap discharges through the relay coil and pulls in the relay. This disconnects the cap from the circuit and switches the coil over to the 12-volt line, which latches the relay on. The 330 Ω resistor bleeds off any charge remaining in the cap. When the button is pressed again, the coil sees a shorted (fully discharged) capacitor and the relay drops out. This applies voltage to the capacitor, which recharges anew.

The second (Figure 9) is built around a JK flip-flop. When power is first applied, the reset line is held low by a 1 µF cap. This forces the complement output high so that the relay is in the off state. The 1 µF cap swiftly charges, which pulls the Reset input high and arms the flip-flop. JK flip-flops are natural toggle switches and are often cascaded in ripple counters for counting input pulses. So, when you press the push button, the flip-flop flips states and turns on the relay via the driver transistor. Push the button again and off goes the relay. The input of the 74HCT73 has a Schmitt trigger, so debouncing of the switch is readily accomplished by hanging an R/C timing circuit (100K/0.22 µF) on the input.

MAILBAG

Dear TJ,

In the January 2004 issue, Mark Farrall requested help in designing a circuit that would be used for both oscilloscope vertical scale calibration and scope probe compensation adjustment. Your suggestion to use a 78L05 for the voltage reference is an excellent solution for vertical scale calibration. Unfortunately, using a 1 MHz square wave for probe compensation adjustment presents a few problems.

A typical scope probe has an internal 9 MΩ resistor, which, in series with the scope's 1 MΩ input impedance and 10 to 25 pF shunt, creates a 10:1 voltage ratio (Figure 10). At low frequencies, all of the load current goes through the resistive divider; at high frequencies, the current through the capacity divider swamps the resistive component. For the above resistor and capacitor values, the crossover occurs at about 1 kHz.

Instead of calibrating the resistive and capacitive divider separately with variable frequency sources, most scope probe calibrators use a 1 kHz square wave, which has a Fourier fundamental component slightly below the corner frequency and many higher odd harmonics

above the corner. Thus, the resistive divider sees mainly the fundamental, while the capacitive divider sees the higher frequency harmonics.

To generate the perfect square wave, the fundamental and all harmonics must remain in the correct amplitude and phase. One simple adjustment of the probe's 15 pF capacitor makes this a simple calibration.

The circuit you presented as Figure 7 on page 80 could be simply modified to generate a 1 kHz square wave by replacing the 1 MHz crystal with an RC combination.

These are fun things to do ... I really enjoy your articles!

Carl Baumgaertner
Engineering Dept.
Harvey Mudd College

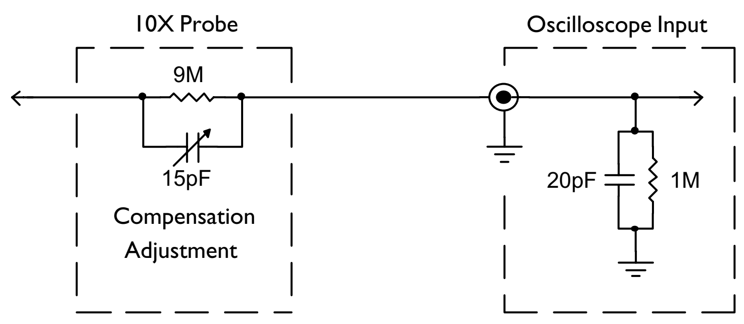


Figure 10 **Typical Oscilloscope Probe**

Dear TJ,

I believe you dropped a zero in answering the February 2004 question about the necessary filter capacitor size for a 5 V power supply desired to have 100 mV ripple at 1 A ("Power Supply Design 101"). The correct answer is 83,000 µF, not 8,300, as stated. Your formula is correct, but your computation is in error.

You can do this in your head if you remember that, for 1 V of ripple at 1 A current, you need 8,300 µF. 1 V x 1 A = 8,300 µF, which you can simply scale to other values. For example, 1 V ripple at 0.5 A is 8,300/2 or 4,150 µF. The constant 8,300 µF for 1 V x 1 A formula, of course, is only for full-wave rectification at 60 Hz.

Jack Smith
Clifton, VA

Dear TJ,

Your answer to the "Basic Electronics 101: Capacitance" question in the March 2004 issue says that the charge increases when you pull the plates apart. This is not true.

The voltage increases, but the number of extra protons on one plate and extra electrons on the other plate does not change. When you pull the plates apart, you have more potential energy, just like lifting a ball higher off the ground gives it more potential energy. The charge on the plates stays the same, as does the mass of the ball.

Viktors Berstis
Austin, TX

Viktors,

I fell into the same trap that many people do — I unintentionally exchanged the term "potential" for "charge." By definition, charge is a number of electrons measured in coulombs, where one coulomb (1C) equals 6.24 quadrillion (6.24 x 10^{18}) electrons. Voltage — also called electromotive force — is a quantitative expression of the potential difference in charges between two points in an electrical field. One coulomb equals one volt of potential. A capacitor of C farads with V volts across its plates will contain Q coulombs of stored charge (Q = CV).

The energy stored in a capacitor is equal to the work done to charge it (U = 1/2 CV^2). Where stored energy U is in joules. When the plates are physically separated, the stored energy is increased and so is the potential (voltage), but not the charge (C), which remains constant.

*Where I tripped up was the **energy** of one electron — which equals .62 x 10^{-19} coulombs — is the reciprocal of a coulomb **charge**. I'm sorry for the mix-up.* **NV**

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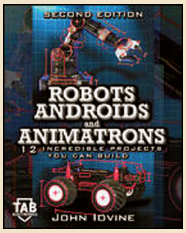

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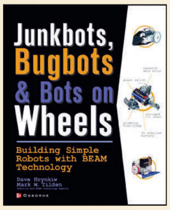
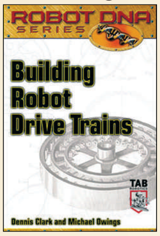
by David Hrynkiw / Mark Tilden



Ever wonder what to do with those discarded items in your junk drawer? Now, you can use electronic parts from old Walkmans, spare remote controls, and even paper clips to build your very own autonomous robots and gizmos. Get step-by-step instructions from the Junkbot masters for creating simple and fun self-guiding robots safely and easily using common and not-so-common objects from around the house. Using BEAM technology, ordinary tools, salvaged electronic bits, and the occasional dead toy, construct a solar-powered obstacle-avoiding device, a mini-sumo wrestling robot, a motorized walking robot bug, and more. Grab your screwdriver and join the robot building revolution! **$24.99**

Building Robot Drive Trains

by Dennis Clark / Michael Owings



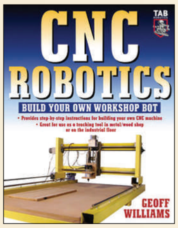
This essential title is just what robotics hobbyists need to build an effective drive train using inexpensive, off-the-shelf parts. Leaving heavy-duty "tech speak" behind, the authors focus on the actual concepts and applications necessary to build — and understand — these critical force-conveying systems. **$24.95**

Everything you need to build your own robot drive train:

- The Basics of Robot Locomotion
- Motor Types: An Overview
- Using DC Motors
- Using RC Servo Motors
- Using Stepper Motors
- Motor Mounting
- Motor Control
- Electronics Interfacing
- Wheels and Treads
- Locomotion for Multipods
- Glossary of Terms, Tables, and Formulas

CNC Robotics

by Geoff Williams



Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **$34.95**

Mobile Robots: Inspiration to Implementation, Second Edition

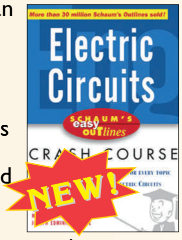
by Joseph L. Jones / Anita M. Flynn / Bruce A. Seiger

Revised and updated, the second edition includes several new chapters with projects and applications. Robotics has made quantum leaps since the first publication of *Mobile Robots: Inspiration to Implementation.* With the publication of the second edition, the authors keep pace with the ever-growing and rapidly expanding field of robotics. The new edition reflects technological developments and includes programs and activities for robot enthusiasts. Using photographs, illustrations, and informative text, *Mobile Robots* guides the reader through the step-by-step process of constructing two different and inexpensive — yet fully functional — robots. **$34.00**

Electronics

Schaum's Easy Outline of Electric Circuits

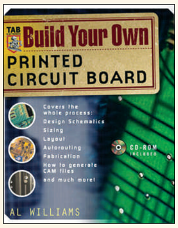
by Mahmood Nahvi / Joseph Edminister



What could be better than the bestselling Schaums Outline series? For students looking for a quick, nuts and bolts overview, there's no series that does it better. Each book is a pared-down, simplified, and tightly focused version of its predecessor. With an emphasis on clarity and brevity, these new titles feature a streamlined, updated format and boil down the absolute essence of the subject, presented in a concise and readily understandable form. Graphic elements — such as sidebars, reader-alert icons, and boxed highlights — stress selected points from the text, illuminate keys to learning, and give students quick pointers to the essentials. **$8.95**

Build Your Own Printed Circuit Board

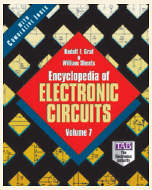
by Al Williams



With *Build Your Own Printed Circuit Board*, you can eliminate or reduce your company's reliance on outsourcing to board houses and cut costs significantly. Perfect for advanced electronics hobbyists as well, this easy-to-follow guide is by far the most up-to-date source on making PCBs. Complete in itself, the handbook even gives you PCB CAD software — on CD — ready to run on either Windows or Linux. (Some PCB software costs from $10,000.00 to $15,000.00!) **$27.95**

Call 1-800-783-4624 today! Or order online at www.nutsvolts.com

Encyclopedia of Electronic Circuits, Volume Seven
by Rudy Graf

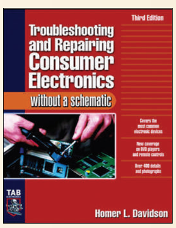


Designed for quick reference and on-the-job use, the *Encyclopedia of Electronic Circuits*, Volume Seven, puts over 1,000 state-of-the-art electronic and integrated circuit designs at your fingertips. This collection includes the latest designs from industry giants, such as Advanced Micro Devices, Motorola, Teledyne, GE, and others, as well as your favorite publications, including *Nuts & Volts*! **$39.95**

Electronic Gadgets for the Evil Genius
by Robert Iannini

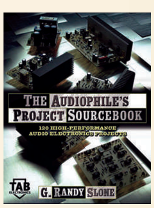
The do-it-yourself hobbyist market, particularly in the area of electronics, is hotter than ever. This books gives the "evil genius" loads of projects to delve into — from an ultrasonic microphone to a body heat detector, all the way to a *Star Wars* Light Saber. This book makes creating these devices fun, inexpensive, and easy. **$24.95**

Troubleshooting & Repairing Consumer Electronics Without a Schematic
by Homer Davidson



In this book, Homer Davidson gives you hands-on, illustrated guidance on how to troubleshoot and repair a wide range of electronic products — when you can't get your hands on the schematic diagrams. He shows you how to diagnose and solve circuit and mechanical problems in car stereos, cassette players, CD players, VCRs, TVs and TV/VCR combos, DVD players, power supplies, remote controls, and more. **$34.95**

The Audiophile's Project Sourcebook: 120 High-Performance Audio Electronics Projects
by G. Randy Slone

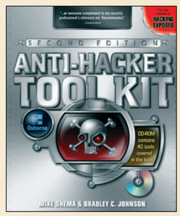


The Audiophile's Project Sourcebook is devoid of the hype, superstition, myths, and expensive fanaticism often associated with high-end audio systems. It provides straightforward help in building and understanding top quality audio electronic projects that are based on solid science and produce fantastic sound! **$29.95**

PSpice for Basic Circuit Analysis
by Joseph Tront

PSpice for Basic Circuit Analysis introduces readers to the fundamental uses of PSpice in support of basic circuit analysis. This book is designed so that the reader can advance rapidly to solve a variety of circuit analyses. Although the fundamental capabilities of PSpice are covered in this book, the principles can be easily extended to analyze the complex electrical and electronic networks used in modern integrated circuit design today. **$24.00**

Anti-Hacker Tool Kit, Second Edition
by Mike Shema / Brad Johnson



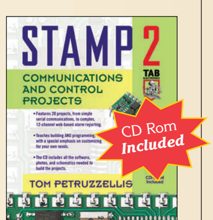
Get in-depth details on the most effective security tools and learn how to use them with this hands-on resource. A must have companion to the bestselling security book *Hacking Exposed*, this tool kit includes tips and configuration advice for getting the best results from the top hacking tools created and in use today. **$59.99**

Microcontrollers

Microprocessor Design Made Easy: Using MC68HC11, with CD ROM
by Raj Shah

This informative, hands-on training book explains Microprocessor Design using the Motorola MC68HC11. It explains, in detail, how the microprocessor works, including its architecture and its addressing modes. It also explains, in easy-to-understand language, the fundamentals of programming. Every chapter in the workbook ends with questions. This study guide uses EZ-Micro Tutor Board from AMS. **$35.00**

STAMP 2: Communications and Control Projects
by Thomas Petruzzellis



With the help of detailed schematics, informative photos, and an insightful CD-ROM, *STAMP 2: Communications and Control Projects* leads you step-by-step through 24 communications-specific projects. As a result, you'll gain a firm understanding of Stamp 2 and its programming methodologies — as well as the ability to customize it for your own needs and operating system. **$29.95**

The *Nuts & Volts* of BASIC Stamps, Volumes 1-4

$9.95 Volume 3

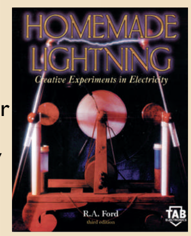
$14.95 Volume 4

$49.95 All 4 Volumes

In 1995, Scott Edwards began authoring a column on BASIC Stamp projects in *Nuts & Volts Magazine*. The column quickly became a favorite of *Nuts & Volts* readers and continues today with Jon Williams at the helm. *The Nuts & Volts of BASIC Stamps* is a four-volume collection of over 100 of these columns.

High Voltage

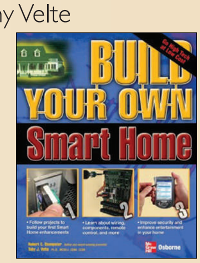
Homemade Lightning: Creative Experiments in Electricity
by R. A. Ford



Enter the wide-open frontier of high-voltage electrostatics with this fascinating, experiment-filled guide. You'll discover how to make your own equipment, how electricity is used in healing, and how experiments in high potential physics work! **$24.95**

Home Entertainment

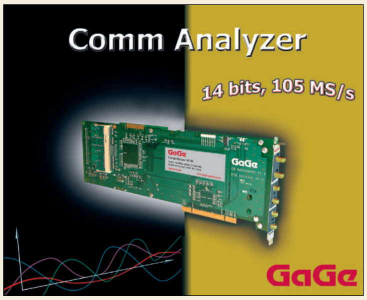
Build Your Own Smart Home
by Anthony Velte



Wow! If you've got the time and inclination, there isn't anything that cannot be automated in your home. This one stop resource uses clear, step-by-step instructions and illustrations to show you how to plan and install smart home systems. Discover projects for automating entertainment systems, home security systems, utilities, and more. **$29.99**

If you don't see what you need here, check out our online store at **www.nutsvolts.com** for a complete listing of the titles available.

COMMUNICATION ANALYZER WITH 14 BITS, 105 MS/s ON 2 SYNCHRONOUS CHANNELS



Gage Applied Technologies, Inc., is thrilled to announce the release of a new 14-bit, 105 MS/s digitizer for the PCI platform. The new CompuScope 14105 comes from a long tradition of signal capture cards and constitutes an evolutionary step in the PC-based digitizer technology that Gage has developed since the late 80s.

"The CompuScope 14105 was designed primarily to solve an important communications test application. Unlike other specialized digitizer modules, this card remains flexible enough to go way beyond I&Q and power spectrum testing," indicated Andrew Dawson, Ph.D., Worldwide Sales Manager at Gage Applied Technologies. "This card has a large FPGA that we will soon open to our customers for programming and a new memory architecture and technology that allows us to reduce the cost."

The card, nicknamed the Comm Analyzer, provides two simultaneous input channels, 14 bits of vertical resolution, 105 MS/s simultaneous sampling rate, over 250 MHz of bandwidth, time-stamping, external triggering and external clocking, as well as trigger and clock output signals for maximum ease of synchronization with other system modules. The single input range of 0.5 V RMS is coupled to a transformer with 50 Ω of impedance, satisfying a key wireless communications test requirement. Accuracy is typically ±0.5% of full-scale input with excellent linearity. The card comes standard with 16 MS of memory, making eight MS available to each of the two channels. The CS14105 can also be equipped with up to 1 GS of total onboard memory and can use 32-bit, 66 MHz PCI standards to transfer data at 200 MB/s.

Completely programming-free operation of the CompuScope 14105 is possible with the world-renowned GageScope® oscilloscope software, allowing the user to easily set up the digitizer and acquire, view, archive, and analyze signals. Gage also offers Software Development Kits (SDKs) for C/C++, MATLAB®, and, of course, the very popular LabVIEW® environment, with support for Windows NT, 2000, and XP.

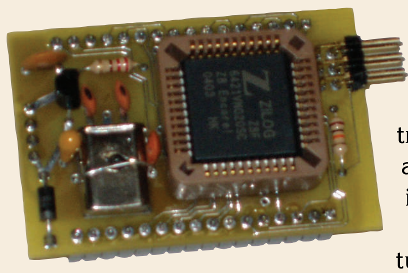
The CompuScope 14105 is available immediately with a projected lead-time of six weeks ARO for small quantity orders. List price for the CompuScope 14105 starts at US $5,995.00 for the base memory model (eight MS per channel, 16 MS total onboard). Volume-based discounts are available to qualified OEMs.

For more information, contact:

GAGE APPLIED TECHNOLOGIES, INC.
2000 32nd Ave.
Lachine, QC H8T 3H7
Canada
800-567-GAGE Fax: **800-780-8411**
Web: **www.gage-applied.com** or **www.kscorp.com**

Circle #117 on the Reader Service Card.

$69.00 EMBEDDED CONTROLLER INCLUDES FREE C COMPILER



MCU Research has introduced the cz8™ family of embedded microcontroller design kits aimed at hobbyist, robotic, and industrial control applications. These kits feature a high level C language function library that makes programming as easy as BASIC language-based controllers. All kits come with a Windows IDE C compiler at no additional cost.

The Module-1 and Proto-1 products feature 31 I/O pins, 64 K of ROM for program storage and 4 K of RAM for variables and stack. Other features include two hardware UARTs, PWM, PCI, and three-wire interfaces, as well as a 12-bit, eight-channel, Analog-to-Digital converter.

For more information, contact:

MCU RESEARCH
276 Jones Cove Rd.
Asheville, NC 28805
Tel: **828-298-6561**
Email: **sales@mcuresearch.com**
Web: **www.mcuresearch.com**

Circle #140 on the Reader Service Card.

QUARTZ HALOGEN LAMPS

Gilway Technical Lamp introduces an expanded line of ANSI coded quartz halogen lamps with built-in reflectors for use in microscope and fiberoptic illuminators.

These lamps come in standard and custom configurations that range from 6 to 1,000 watts, with C-Bar-6, transverse,

and axial filaments. Featuring integral polished aluminum, gold, and dichroic reflectors, these lamps are available in a wide variety of base types and can be supplied with or without UV and IR blockers.

Suitable for OEM and replacement applications, these lamps come in G4, GY6.35, GY9.5, GX5.3, GX7.9, PG22, bi-pin, and DC bayonet base types and are available with holders, wiring, and connectors.

Gilway Quartz Halogen Lamps are priced from $2.00 each, depending upon style and quantity.

For more information, contact:

GILWAY TECHNICAL LAMP
55 Commerce Way
Woburn, MA 01801
781-935-4442
Fax: **781-938-5867**
Email: **sales@gilway.com**
Web: **www.gilway.com**

Circle #49 on the Reader Service Card.

INSULATED MALE TABS

ETCO introduces Fully Insulated Male Tabs that feature an "F" crimp wire attachment that holds the wire without crushing it and has a nylon insulator to eliminate the need for shrink tubing or hand blocking.

By providing a stronger attachment than closed barrel crimp connections, they are ideal for high-vibration applications.

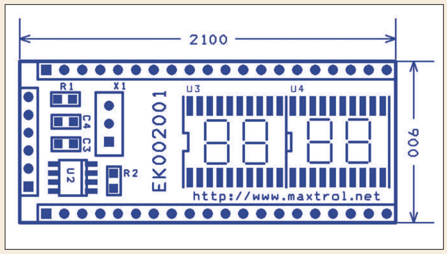
ETCO Fully Insulated Male Tabs are UL/CSA approved; they are offered in brass and tin-plated brass in three sizes. Prices are according to type, style, and quantity.

For more information, contact:

ETCO INCORPORATED
25 Bellows St.
Warwick, RI 02888
401-467-2400
Fax: **401-941-2453**
Email: **info@etco.com**
Web: **www.etco.com**

Circle #78 on the Reader Service Card.

PROTOTYPING BOARDS



Addressing the needs of electronics engineers, Maxtrol created these prototyping boards to make engineering work

easier and more practical.

The MultiPro reduces design time; just insert the MultiPro into the breadboard, wire it to the target circuitry (if there is one); then, just program and test it. A MultiPro (Multi-Project) is a tool that can be used to develop many different projects. It contains all of the basic components that a microcontroller needs to function properly.

Then, when a concept is probed or a permanent circuit system is needed, Maxtrol offers Prototyping boards with the same functionality as the MultiPros, but with a prototyping area for the addition of target circuits.

Since most microcontroller projects require numeric displays, some of our Multipros have a four-digit numerical LED display integrated in a very small package (around the size of a DIP-40 IC). Practically speaking, most projects just need to be programmed.

Due to their small size, they are ideal for robotics and other applications that demand small control units, probing a concept, quick development, lab practices, learning PICs and AVRs, programming microcontrollers, etc. In addition to their products, Maxtrol also offers the following services:

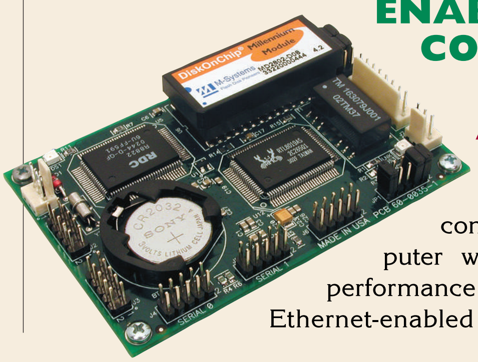
- Design of custom electronic circuits (analog/digital/microcontroller).
- Artwork design.
- Design and building of electronic prototypes.
- Custom test equipment design.

For more information, contact:

MAXTROL CORPORATION
(281) 879 6883
Fax: **281-879-0321**
Web: **www.maxtrol.net**

Circle #128 on the Reader Service Card.

ETHERNET ENABLED DOS CONTROLLER



At $98.00 per unit, JK microsystems' new picoFlash is a 186 compatible DOS computer with Ethernet whose performance rivals competitor's Ethernet-enabled products for a

fraction of the cost.

Slightly larger than a credit card, the picoFlash is a fully programmable, compact, single board computer ideally equipped for data acquisition, industrial, control, and communications applications.

Standard units feature a fast, 40 MHz RDC R8822 microprocessor, NE2000 compatible Ethernet, 512 K DRAM, and 512 K Flash memory, two serial ports, 16 bits of I/O, hardware clock/calendar, and a socket to expand non-volatile memory using M-Systems DiskOnChip products.

The preloaded, royalty-free DOS operating system and flash file system provide a fast, yet convenient, environment for embedded development. Along with a watchdog timer, 5 V DC power, RS-485 serial port capability, LCD support, and aggressive pricing, the picoFlash single-board computer covers many embedded Ethernet designs for the OEM market.

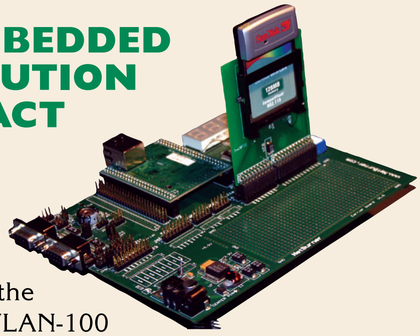
Available development kits are $129.00 and include a picoFlash controller, necessary cables, Borland C/C++ version 4.52 compiler, driver libraries, and documentation. Free technical support from JK microsystems' engineers is available via Email or the new online Support Forums at **http://forums.jkmicro.com**

For more information, contact:

JK MICROSYSTEMS
1403 5th St., Ste. D
Davis, CA 95616
Tel: **530-297-6073**
Email: **jkmicro@jkmicro.com**

Circle #151 on the Reader Service Card.

LOW COST EMBEDDED WIRELESS SOLUTION USERS COMPACT FLASH WiFi CARDS



NetBurner, Inc., announces the addition of the NBWLAN-100 complete embedded wireless solution. The NBWLAN includes both the wireless hardware and software to quickly and easily add 802.11b WiFi to new and existing embedded products. The NBWLAN uses standard, off-the-shelf WiFi compact Flash-style cards that provide

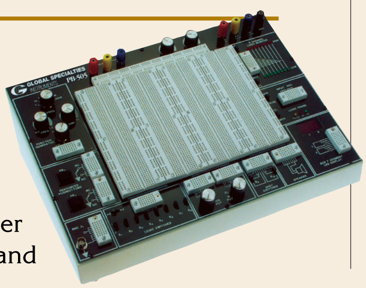
both low cost and a small form factor. It also enables upgrades to higher speed wireless networks, such as 802.11g. The NBWLAN-100 development board is $249.00 and includes the WiFi card. The NBWLAN is part of the NetBurner Network Development Kit that includes an Integrated Development Environment (IDE), RTOS, TCP/IP stack, web server, C/C++ compiler, debugger, and deployment tools.

For more information, contact:

NETBURNER, INC.
5405 Morehouse Dr.
San Diego, CA 92121
Tel: **800-695-6828**
Email: **sales@netburner.com**
Web: **www.netburner.com**

Circle #133 on the Reader Service Card.

MODEL PB-505 ADVANCED CIRCUIT DESIGN TIMER



Global Specialties — a leader in the manufacturing and sales of three year warrantied test equipment products and prototyping design trainers and breadboards — has just released a new Advanced Proto-Board Design Trainer.

The model PB-505 has a retail price of $475.00, but offers a significant group of exceptional features and functions for bench circuit design in engineering and R&D labs, as well as for many colleges, universities, and vocational schools where electronic engineering and computer engineering courses are offered. Housed in a rugged steel case, the PB-505 offers a lifetime guarantee on all breadboarding sockets and a three year warranty on all other parts and workmanship. Included with this advanced trainer — which is ideal for higher levels of analog, digital, and microprocessor circuit design — is:

- Expandable, removable breadboard area
- Built-in, multi-waveform function generator
- Quad voltage power supplies — three DC variable and one AC
- Built-in logic probe with pulse capture
- Two open collector output pulsers
- Eight channel logic indicators
- Eight individual SPDT logic switches and two SPDT separate switches
- BCD to seven segment decoder LCD display
- Built-in speaker, 1K and 10K variable potentiometers

For more information, contact:

GLOBAL SPECIALTIES
Highland Industrial Center
1486 Highland Ave., Unit 2
Cheshire, CT 06410
800-572-1028 Fax: **203-272-4330**
Web: **www.globalspecialties.com**

Circle #124 on the Reader Service Card.

ION AIR GUN

EXAIR's Ion Air Gun removes static electricity, contaminants, and dust from three-dimensional parts prior to labeling, assembling, packaging, painting, or finishing. It is engineered for safe operation and is now UL Component Recognized to US and Canadian safety standards. The shockless Ion Air Gun neutralizes static electricity and cleans at distances of up to 15 feet (4.6 m).

The Ion Air Gun incorporates a high velocity air jet that uses a small amount of compressed air to entrain 80% of the total output airflow from the surrounding room air. An electrically energized emitter at the discharge end fills the entire airstream with positive and negative ions capable of neutralizing high static charges in a fraction of a second. An optional regulator allows infinite adjustment of the air volume and velocity. A comfortable grip for hand positioning allows hours of continuous use without fatigue.

This gun is quiet and features a hanger hook for easy storage. The 10 foot, shielded power cable is very flexible and is designed for rugged use. The gun is ideal for cleaning molded parts, pre-paint dust removal, furniture finishing, and package cleaning prior to labeling or printing. Price is $285.00.

For more information, contact:

EXAIR CORPORATION
1250 Century Cir. N.
Cincinnati, OH 45246
800-903-9247 Fax: **513-671-3363**
Email: **techelp@exair.com**
Web: **www.exair.com/iag.htm**

Circle #86 on the Reader Service Card.

Is Your Laptop Trustworthy?

If it doesn't have a TPM (trusted platform module) chip on the motherboard, then it may not be trustworthy. According to Atmel (**www.atmel.com**) — which has sold over 5,000,000 of its AT97SC3201 TPM integrated circuits for installation on laptops — the hardware implementation of digital security is the future.

A TPM chip interacts with both the OS and application software to digitally sign Email and store both passwords and encryption keys in a memory space that is not on the hard drive — and is thus inaccessible to malicious programs. TPM security is based on an industrial standard developed by the Trusted Computing Group (TCG) and includes support for fast 2048-bit RSA crypto acceleration, true random number generation, secure EEPROM storage, and tamper prevention circuitry that disables the chip if illegal snooping is detected.

The services of TPM hardware may become the next "killer app" as ways are sought to quench spam Email and protect user privacy on the Internet. More information on TCG principles is available online: **www.trustedcomputinggroup.org**

Why, It's Wafer Thin!

Most of us are used to the compact flash (CF) cards in our portable MP3 players and digital cameras. Every six months or so, some newspaper advertisement offers a 2x jump in size for the same $150.00 — a trend that seems to be without end.

Well, did you know you can just leapfrog toward the endgame with Hitachi's 3K4 Microdrive product? If you've never heard of it, the 3K4 — offered in two and four gigabyte capacities — is the same physical size as CF media, but it's a real spinning hard disc!

Users of high-performance digital cameras report that the write time is slower than that of solid-state CF media, so it may not be suitable for some users.

For the rest of us, though — viola! There's even a way to get it on the cheap. Wired News online (**www.wired.com**) reports that the $200.00 MuVo2 portable MP3 player from Creative Technology uses the four gigabyte size Microdrive.

So, if you're in the mood to cannibalize this unit — you can save about $300.00. Not bad for a opportunity to take something apart — without even having to put it back together.

Muscle Toys

A new toy has been produced containing a groundbreaking technology — NanoMuscles. Named "Ojarumaru Man," it is currently available in McDonald's restaurants throughout Japan.

O-Man is a talking, moving toy modeled after a famous Japanese anime character. The NanoMuscle motor inside of O-Man replaces a traditional field-wound electric motor, gearbox, and slip clutch to reduce both complexity and cost.

A NanoMuscle utilizes a stacked array of shape memory alloy (SMA) wires to build up the total force it can apply to a load. SMA contracts when a small current is passed through it and relaxes when the current is removed, allowing it to be stretched back to its original length.

The energy density of SMA is over 4,000 times that of its electromechanical counterpart, which makes it of great interest to the price-sensitive consumer marketplace.

NanoMuscle, Inc., is a leader in the next generation motor market, manufacturing numerous SMA-based devices. They even have development kits for sale on their website: **www.nanomuscle.com**

All That Jazz

Under contract with Magnolia Broadband, chip fabricator Jazz Semiconductor of Newport Beach, CA is ready to ramp production on a clever new formulation of silicon and germanium, surprisingly named "SiGe." With a current-gain cut-off frequency above 200 GHz, the SiGe process will be used in Magnolia's DiversityPlus™ chipset — a new scheme to improve cell phone reception by adding a second antenna input and incorporating a clever algorithm to extract weak signals.

By using SiGe, power consumption is greatly reduced without sacrificing computing throughput. This is yet another example of how traditional analog functions are moving into the domain of digital signal processing.

Also, with over 200,000,000 cell phones in use worldwide, there is intense pressure on developers to increase performance while decreasing cost.

by Steve Russell

PIC-Based Archos Remote Control

A Great Use for a Small PIC

This project provides a wired remote control for certain members of the Archos family of hard disk-based Jukebox MP3 players and recorders. Key features of the design are:

- Low component count and cost.
- Simple construction.
- Compatible with a small enclosure.
- Runs off a single battery.
- Long battery life.

Introduction

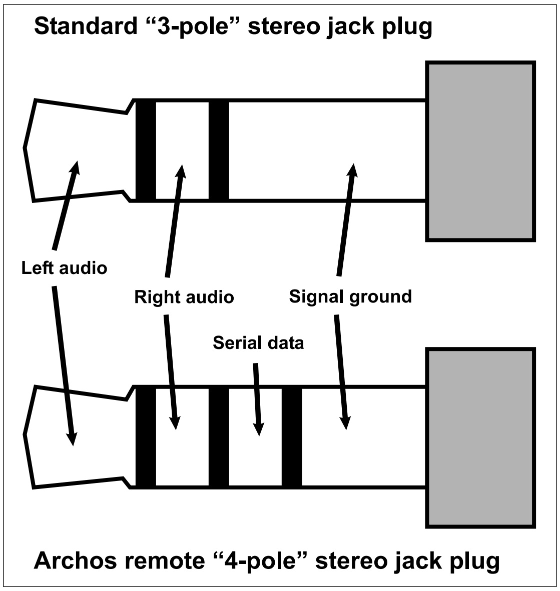
Although there are now many different audio compression technologies available, MP3 is, without dispute, the most widespread and best supported of those used for moving music around on the Internet and for carrying it with you as you travel. Following on the heels of small capacity (64-128 MB) solid-state players that hold about an hour or two of music, there are now a number of hard disk-based MP3 players and recorders available, such as those offered by Archos (**www.archos.com**).

While not as robust as the solid-state players — which have disk sizes up to 20 GB — these devices can store the equivalent of 300 CDs in MP3 format — even more if you are prepared to sacrifice sound quality for greater compression. The good news is that they are becoming more affordable as the cost of disk storage continues its downward trend. While most would agree that they lack the elegance of products such as the Apple iPod, the Archos players come with a much more palatable price tag.

Price is not the only advantage that Archos can claim over its rivals. Several of the company's products have attracted an active open-source community that is developing alternative software for them. This software, called Rockbox (**http://rockbox.haxx.se**), is rapidly becoming superior to the standard software. The Rockbox site also offers lots of information about the Archos hardware and ways in which to modify it, either directly or via pointers to other websites. I've upgraded my 20 GB Jukebox Recorder with a 40 GB drive, thanks to information available there. This is a relatively simple upgrade, but there are more tricky ones to be found if you like modifying your gadgets and feel adventurous.

Looking through the mailing list hosted at the Rockbox site, I found enough information to be able to design and construct a wired remote control for my recorder. Archos offers a remote, but only as a component within a complete travel kit that also includes a power adapter, cassette adapter, and headphones — all of which I already have. Building my own remote seemed to be a much better option than paying for things I didn't need.

Figure 1. Tip and ring connections.



This Month's Projects

The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

Using the Remote With Your Jukebox

The remote control described here should work with all Archos Jukebox Recorder and Jukebox Studio devices (see Sidebar). For convenience, I'll just say recorder from now on when referring to all supported players and recorders.

A stereo headphone jack plug has a tip, ring, and sleeve to provide the connections to the left and right audio signals and the ground reference. The recorder has an extra connection for the remote in the headphone socket, which is grounded when a normal headphone jack plug is connected. The remote jack plug has an additional ring that is used to transmit the commands from the remote to the recorder. The headphones are then plugged into the remote, which passes the audio straight through to them. These connections are illustrated in Figure 1.

How Does the Remote Work?

The remote communicates with the recorder using a simple, eight-bit, asynchronous serial protocol, with the least significant bit (LSB) first — at 9,600 bits per second — using one start and one stop bit. Six commands are defined — one each for Play, Stop, Volume Up, Volume Down, Next, and Previous. The details are shown in Figure 2.

These six commands work for both the standard Archos software and the alternative Rockbox offering. The remote code was designed so that it is a straightforward process to add additional commands to the standard ones. This means that it is relatively simple to modify the code to implement additional commands, should the Rockbox developers add functions (or, since Rockbox is open source, should you decide to add your own).

Implementation

One of the key design goals I had was creating a remote that would fit into a small, neat package. It is difficult to achieve this with a home brew design, but a remote the same size as the recorder was not the answer. To keep the size down, I decided to use one of the smaller, eight-pin, low voltage PIC processors, with the intent of using a surface mount device (SMD) to minimize the size of the completed unit.

Picking the PIC

I already had some experience with the PIC12C508A (see my High-Roller article, *Nuts & Volts*, January 2003), and felt that this project would also suit this class of microcontroller (MCU). In addition, Microchip offers a low voltage part (PIC12LC508A) — available in both DIP and SMD packages — which will run from a 3 V supply. With careful design for minimizing power, this means that a single CR2032 coin cell will supply sufficient power to operate the device for an extended period — estimated at well over a year.

Hardware

The '508A family of devices has eight pins. Two of these are for power, with the remaining six being input/output (I/O) pins that support a number of different modes. The device's configuration bits determine their function. In this design, they are all used as normal I/O pins.

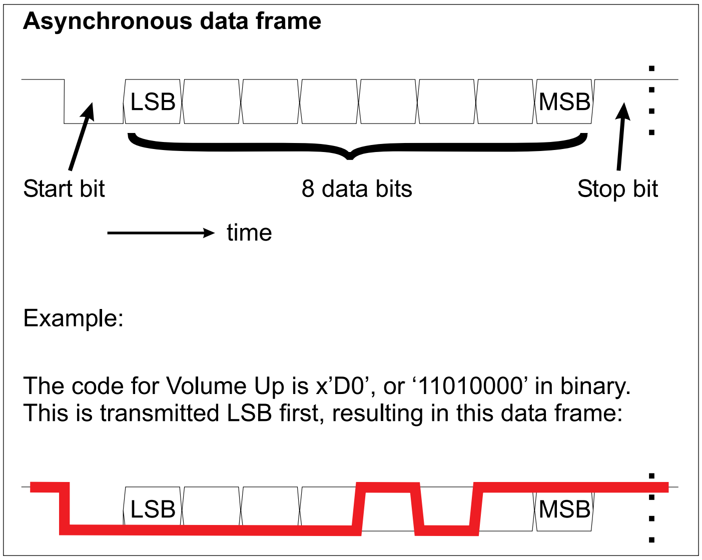
Is My Player or Recorder Supported by the Remote?

Be sure to check the Archos website (**www.archos.com**) to make sure that the remote in the Archos travel kit supports your player or recorder before embarking on this project. At the time of writing, the Jukebox Recorder and Jukebox Studio (player) devices are supported — not the FM Recorder or Jukebox Multimedia devices. If your device is supported, this remote should also work as well or better than the Archos one, particularly if you also use the Rockbox software.

Making Sure the MCU Clock Is Accurate

An individual oscillator calibration value is stored at address 0 x1FF in each '508A during manufacturing. This value must be loaded into the OSCCAL register to ensure the best accuracy for the internal clock. Check your programmer information carefully to make sure you don't overwrite this value when programming your PIC.

Figure 2. Serial data.



Referring to the schematic in Figure 3, two outputs of the PIC12LC508A (GP4 and 5) drive a 2 x 3 matrix of switches. The switch states are read in using inputs GP0, 1, and 3, which are equipped with weak internal pullups (determined by the device's configuration bits), so no external resistors are required. These inputs also support "wake on pin change," which allows the PIC to sleep while waiting for a switch to be pressed. The final output (GP2) drives the serial data to the Archos Jukebox.

The configuration fuses are set to use the internal oscillator (leaving all six I/O pins available for use). All timings are therefore calculated assuming a nominal 4 MHz clock, so each instruction cycle takes 1 µs.

Useful Websites

Rockbox
http://rockbox.haxx.se

Archos discussion group
http://groups.yahoo.com/group/archosjukebox6000

PIC MCU information
www.microchip.com

PIC discussion group
www.piclist.com

Eagle PCB layout software
www.cadsoft.de

Design Details

The basic code design is straightforward. All the remote has to do is transmit the appropriate command to the recorder when a switch is pressed. However, there are a number of factors that make things a little more complicated. These are:

- Providing an open-drain drive to the Archos, even though the '508A's drivers have totem pole outputs.
- Minimizing power consumption.
- Debouncing the switches.
- Dealing with invalid key presses and making the design

Don't Blow Up Your Recorder!

During development, I was using a 5 V UV EPROM PIC. If I had inadvertently driven a logic 1 from GP2 while the TRIS register was set to enable the pin, it would have pushed 5 V into the recorder data line. This could well have resulted in permanent damage to my recorder, so I did a lot of testing before connecting the recorder to the prototype. Be careful to thoroughly test your code if you make modifications!

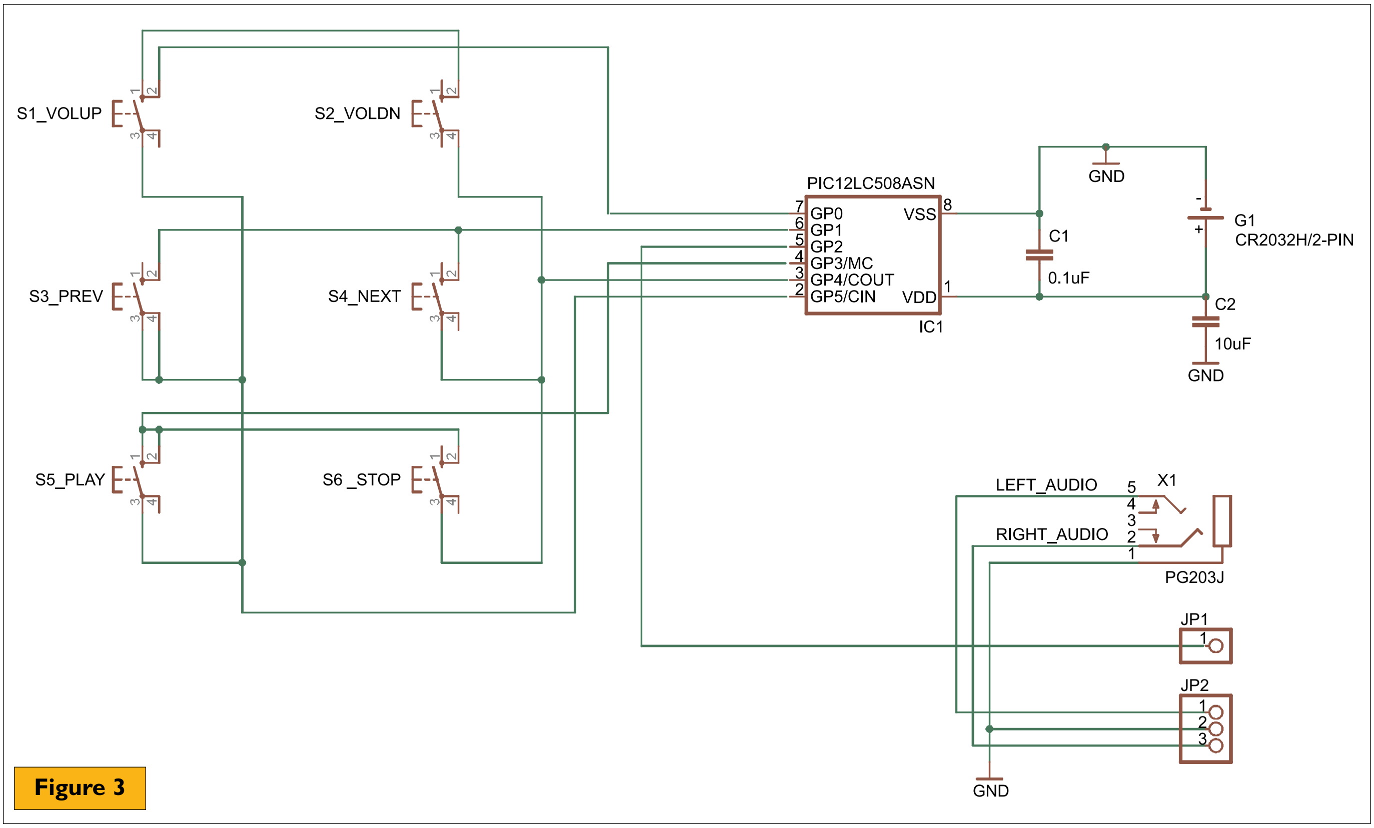


Figure 3

flexible enough to allow additional commands.

• Repeatedly sending the volume adjustment commands if the corresponding switches are held down, so that the volume continues to increase or decrease, as required.

• Making sure that data is transmitted at the correct rate for the Archos to recognize it. The specification of the '508A's internal oscillator timing is not quite as accurate as required for serial communications.

In the following section, I'll cover each of these points in turn. Where appropriate, I'll refer to excerpts of the code included in the article, but you may find it useful to have the complete code listing (available from the *Nuts & Volts* FTP library at **www.nutsvolts.com**) on hand.

Also, if you're not familiar with the '508A's assembly language, it is worth getting the datasheet from Microchip (**www.microchip.com**).

While there's not enough room in this article to discuss the entire code listing, I believe that — armed with the datasheet, the code listing, and the following description — you'll soon understand how the remote works.

Example 1

```
**********************************************************************
'Now we check the button status and repeat this loop until there has
been no change in button state for 10 ms.
'
'NOTE: The timing of this loop is important, since it is used as the
basis for debounce timing. Be careful when modifying the path taken
when the buttons haven't changed — DEBCNT will need to be modified.
**********************************************************************
dbncloop
        call    readbtns; [35] Read the button status.
        movf    btnstat,w       '[36] Get current button state.
        subwf   buttons,f       '[37] Compare with last reading
        movwf   buttons '[38] Save new value. We only need Z flag
        btfsc   STATUS,Z; [39] Have they changed?
        goto    nobtnchg; [41] NO: Need to see if debounced.
        movlw   DEBCNT  'YES: Start debounce timer again.
        movwf   dbnctmr
        movlw   RPTDLY  'Set repeat delay.
        movwf   rptdelay
        goto    dbncloop; ...and go back to read buttons again.

'Buttons didn't change this time around; decrement timer.
nobtnchg
        decfsz dbnctmr,f; [42] Decrement debounce timer; test if done.
        goto    dbncloop; [44] NO: Go back and read buttons again.
```

Driving the Archos

The Archos expects an open-drain driver for serial data. Unfortunately, the '508A does not have an open-drain output. To overcome this limitation, I implemented one by using the PIC's ability to tri-state its output pins.

When the data line is idle, it needs to be at logic 1, which for the Archos recorder is 3.3 V. By tri-stating (disabling) GP2 using the TRIS register, a pullup in the recorder drives the data line to 3.3 V. To put a 0 into the data line, GPIO bit 2 must be set to 0 and then the TRIS register must be set to enable GP2.

Important: Be sure to read the information in the sidebar before making any changes to the code, particularly if you build the remote with a 5 V PIC.

Example 2

```
******************************************************************************
'bitdelay
'
'       INPUT:  The value in bitadjust is initialized at POR to make the
entire loop starting at nextbit in xmit take exactly 104 instruction
clocks. Increasing or decreasing bitadjust by 1 adds or subtracts 1 clock,
respectively, to the serial data bit time.
'       OUTPUT: None
'
******************************************************************************
bitdelay
        movf    bitadjust,w     'Get the necessary adjustment
        movwf   loopcnt 'Save it in the delay loop counter
        bcf     STATUS,C'       but divide by 4 (loop length)
        rrf     loopcnt,f
        bcf     STATUS,C
        rrf     loopcnt,f
        movlw   0x03            'Get mask for low two bits
        andwf   bitadjust,w     ' ...and isolate them
        xorlw   0x03            ' Invert them (0->3, 1->2, 2->1, 3->0)
        addwf   PCL,f           ' Use the number to trim the cycle count.
        nop
        nop
        nop
bit1
        nop                     'This loop is four clocks in length; use
decfsz  loopcnt,f calculated value to generate bit timing.
        goto    bit1
        nop                     'Last time through loop has to be four
clocks, too.
        retlw   0
```

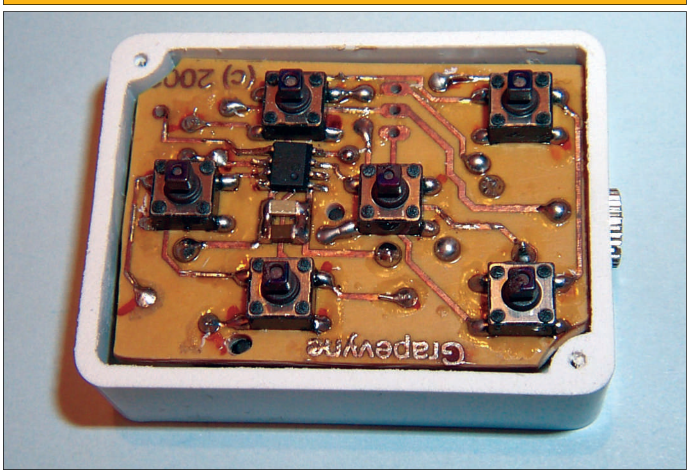
Power Consumption

To keep power consumption to a minimum — thereby extending battery life — the design ensures that the '508A spends most of its time asleep, drawing almost no current (about 2 or 3 µA). The MCU's Option register is set to wake the device up on a pin state change, so that it responds when the user presses one or more of the switches. Other features set in the Option register enable the weak pullup resistors on GP0, 1, and 3 and assign the MCU's pre/post-scaler to the watchdog timer (WDT).

When the user presses a switch, the '508A wakes up and, after debouncing the switch, sends the appropriate command to the recorder before going back to sleep. The WDT is a counter that runs even when the PIC is asleep. When it reaches its terminal count, it wakes the PIC up. In many designs, the WDT is used to reset the MCU if something interferes with the correct operation of the program. For the remote, however, it is primarily used to wake the PIC up when the user is holding one of the volume adjustment switches down. This allows the remote to send multiple commands without the user having to press the same switch repeatedly.

When another switch or no switch is held down, the WDT period is set to its maximum (nominally 2.3 s), since it cannot be completely disabled. By calculating the current drawn by the remote in its various modes and making assumptions about how often the user will press switches, it is possible to calculate its average power consumption. I assumed that the user would make an average of two key presses for every three minute song for eight hours a day. This gives an average current of about 12 µA, which means that a 200 µA CR2032 cell should last for about 700 days — nearly two years.

Figure 4. Printed circuit.



Handling Key Presses

Mechanical switches usually "bounce" when they change state. This means that, rather than changing directly from OFF to ON, they oscillate between OFF and ON for a short time (several milliseconds, typically) before stabilizing in the new state. For a light switch, this isn't really a problem, but, for electronic equipment, the oscillation can be seen as several distinct switch presses instead of just one. If this occurred for a press of the Next switch on the remote, for example, the recorder would skip perhaps four or five songs rather than just moving to the next one to be played.

To "debounce" the switches when the PIC wakes up due to a pin change, it reads the switches multiple times and waits until there has been no change for about 10 ms (set by **DEBCNT**). If the switches change before the 10 ms has expired, the debounce timer is started again. The debounce loop is shown in Example 1.

By the way, if you take a look at the routine that reads the switch status (**readbtns**), you'll see a string of **nop**

instructions (no operation). These allow the switches to be read accurately and are necessary because the pullup resistor on GP3 is about 10x larger than the pullups on GP0 and GP1, causing a delay before this input accurately reflects the switch status.

Once the switches have been debounced, the data read from the switches is converted into a command that is used to determine the necessary action, implemented by a call (actually a goto) to **fntable**. To save space, only one- or two-switch combinations are decoded. If the user presses three or more switches simultaneously, they are ignored.

For the Next, Previous, Stop, and Play switches, a single command is sent to the recorder, even if the switch is held down. When the volume is being changed, however, it is useful to send repeated changes while the switch is depressed. For Volume Up and Volume Down, therefore, the WDT period is made shorter (about 140 ms) prior to sending the initial command and then going to sleep. After an initial delay of about 750 ms, a repeated command is sent every time the WDT wakes the PIC up, until the switch is released.

The six single-switch commands are those we've already discussed. Only one two-switch command is currently implemented — if the Volume Up and Volume Down keys are pressed together and held for more than a couple of seconds, the remote goes into Calibrate mode, which is discussed in the next section. All other two-switch combinations are discarded. If additional commands need to be implemented later, the code can be easily incorporated

Skills

Hardware construction: Rating 2.

The construction of the high-roller is simple. Anyone with basic electronic skills (soldering, reading a schematic, and so on) will be able to put the unit together. You will need to be careful when soldering the surface mount components. Use a fine point soldering iron and work as quickly as you can.

Software: Rating 2

The software is a little more complicated and uses some techniques that require some thought to understand. However, it is well commented and relatively short, so, if you have some familiarity with PIC assembly language, understanding the code will not be difficult.

Programming the device requires that you are able to use a programmer. Alternatively, I can provide a pre-programmed PIC12LC508A for $10.00, including shipping from the UK. Anyone wishing to purchase a pre-programmed chip should first contact me at **pic.projects@ntlworld.com**

Figure 5. The completed remote control.

Tools

Tools for Construction

Construction is straightforward — just make sure you get the '508A situated the right way. The ceramic capacitors I used were not polarized. Take care in soldering the PIC pins in particular to make sure that no solder bridges are formed.

Note that you will need a device programmer to program the PIC12C508A. A quick Google search found many sites from which you can purchase relatively cheap programmers and programmer kits (under $100.00 and some for much less).

Tools for Debug

A multimeter is handy for checking voltages. It is useful to have access to an oscilloscope to make sure the serial data is being transmitted before you actually connect the remote to your recorder. Because GP2 is acting as an open drain output, you'll need to connect a resistor between GP2 and the positive side of the battery to see the data. The resistor value is not critical — 1K to 10K will be fine. Remember to remove it afterward!

If you don't have access to a 'scope, check that there's no significant voltage on the serial data pole of the jack plug and that a resistor pulls it to the battery voltage before trying it on your recorder.

You should also test that the left and right audio paths are working correctly. You can do this easily by connecting some headphones to the remote and briefly connecting a 1.5V AA or AAA battery between the left and right audios and grounds on the four pole jack plug. You should hear clicks only in the selected channel.

As long as you have not made any assembly errors, you'll plug the remote into your recorder and, with a little luck, it will work. If not, you'll need to attempt to calibrate the device as described. If calibration doesn't resolve the problem, check all of your connections and you may find that an oscilloscope is really necessary to complete the debug.

via a link in **fntable**.

Calibration Mode

Asynchronous communication depends on both transmitter and receiver running at the same speed. The recorder expects 9,600 bits per second, which equates to about 104 µs per bit. Since each instruction takes 1 µs to execute, the subroutine that sends commands to the recorder (**xmit**) sends the start bit and then it must take exactly 104 instructions before sending each successive bit. The xmit routine uses some of these 104 instructions up, but calls **bitdelay** to pad the count out to 104.

It can be shown that the accuracy of the MCU clock must be better than ±7.7% to ensure accurate reception of the command by the recorder. The figure for eight-bit commands is actually ±5.8%, but, as the top two bits and the stop bit are all logic 1, the less accurate figure is sufficient. Microchip make the internal clock as accurate as it can (again, see the sidebar), but, even so, the specification for the '508A's clock is +7.75%, -11.25% from 0-70°C. Therefore, calibrate mode allows the user to modify the bit period by ±16 clock cycles (about ±15%) to compensate for the widest deviations from nominal.

Pressing Next or Previous in Calibrate mode decreases or increases (respectively) the transmit bit time by one instruction cycle by modifying the value of **bitadjust**. Because a loop takes a minimum of three instructions, I used an nop instruction to make the loop four clocks long. This allowed me to use the two low order bits to calculate a small jump to add the required extra zero to three clocks. Take a look at Example 2 to see how this works.

While in calibrate mode, a series of Volume Down and Volume Up commands is transmitted so that it is easy to see when the recorder is receiving commands. If the timing is not accurate enough, the commands are ignored. From limited testing, it appears that calibration will not be necessary in most cases, but it is there if it is needed. Full instructions for calibration mode are given in the description near the top of the full code listing.

Switch presses in calibrate mode are handled through another jump table, called **caltable**. Any additional functions that may be required can be easily incorporated via a link in caltable.

Completing the Project

The remote uses few components, so construction is

Acknowledgements

Information required to drive the remote port of Archos devices was gleaned from Tjerk Schuringa, author of the original REMOCLONE remote software (implemented with a 16LF84) and the authors of Rockbox — the amazing open source alternative to the Archos' proprietary firmware.

Parts List

The parts are all very easily sourced from vendors such as Digi-Key, Newark InOne (formerly Newark Electronics), and Future Electronics. Watch out for minimum quantities of the low power PIC12LC508A. Newark InOne sells single chips.

S1-S6	Single-pole, single-throw push to close switch
IC1	PIC12LC508A microcontroller
C1	0.1 µF ceramic SMD capacitor
C2	10 µF ceramic SMD capacitor
X1	Three pole, 3.5 mm stereo jack socket (switched or unswitched)
	Four pole, 3.5 mm stereo jack plug
	Battery holder for CR2032 coin cell

very simple. I decided to make a printed circuit board on which to mount them. The PCB layout was created using the free version of Eagle (**www.cadsoft.de**) and the assembled board is shown in Figure 4. The Eagle schematic and layout files are available from the *Nuts & Volts* FTP site (**www.nutsvolts.com**).

To keep the size down, the battery clip for the CR2032 and the headphone socket are mounted on the opposite side of the switches, PIC, and capacitors. I also used SMD components for the PIC and capacitors. Note that you may have to modify the layout to allow for different battery clip or headphone socket designs.

Because the switches are pin-in-hole devices, this meant that (on my single-sided PCB) I had to solder them on the "wrong" side of the board. For a production design, it would be much better to design a double-sided PCB, with the added benefit of avoiding the need for any links.

Some colored beads to differentiate the buttons, a graphic, and a coat of silver paint complete the remote (Figure 5). With it attached to your recorder, the remote lets you put your recorder somewhere safe — even leaving it in its protective case — with the remote on hand to control it.

Happy listening! **NV**

About the Author

Steve Russell started his working life as a hardware design engineer. Somewhere along the way, he was seduced by computers and began designing subsystems of various types for them, working for a multi-national computer company. Much later — after a spell in development management — he decided that salespeople needed his help and so he moved into technical marketing, but he still misses the baleful green glow of an oscilloscope in a darkened lab, late at night.

Render Up Some Video On Your Next Digital Project

And Find a New Use for an Old Television

Have you ever wanted to add an inexpensive video text display to your project? Well, now you can! The Composite Video Text Display can generate a 40 x 25 character display on a standard television set (see Figure 1). The connection to your television is through the composite video input jack. This is usually the yellow RCA jack located on the back of most modern televisions. If your television does not have this jack, a standard video modulator (RadioShack P/N 15-1214) can be used to send the signal to your set's antenna input on channel 3 or 4. The circuit supports the North American NTSC standard and the common European PAL standard.

Theory of Operation

At the heart of the circuit is an ATmega8 microcontroller made by Atmel Corporation. It has an eight-bit RISC core running at 16 MHz. Its pipelined architecture allows for most instructions to be executed in a single cycle, producing nearly 16 MIPS (16 Million Instructions Per Second). It has 8 K of Flash programmable memory, 512 bytes of EEPROM, and 1,024 bytes of STATIC RAM onboard. It also contains its own power on reset control, internal timers, and up to 23 digital I/O ports. All this is packed into a narrow, 28-pin IC!

With the ATmega8, there is enough speed and internal resources to provide a basic black and white display with a minimum of external parts. The software code only takes 3 K of the program memory, leaving enough space to provide a 512 character font. Display data is stored in the internal RAM. All external components are controlled by the ATmega8 through its digital I/O ports.

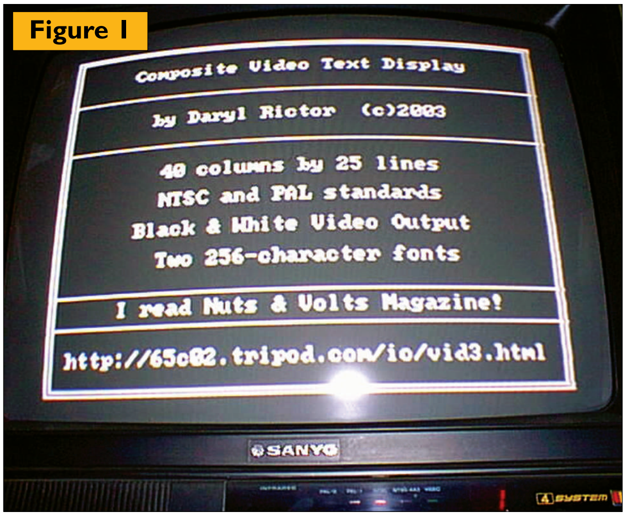
Since the data RAM is only eight bits wide, up to 256 different characters can be displayed on the screen at one time. Therefore, the fonts are organized into two sets. The primary font contains all 256 basic DOS characters, including the accented letters and the box drawing set. These characters are displayed in white on a black background. The alternate set contains 128 standard ASCII characters with some special graphic characters added. It can display white-on-black and black-on-white characters.

Program operation involves two processes (see Figure 2). The main loop receives data from the host device and updates the internal RAM accordingly. Data is placed on the eight-bit input port by the host and a logic high on the strobe input from the host will latch the data. A busy signal is returned to the host. Once the data has been processed, the busy line is released and the next cycle can begin.

The eight-bit data presented at the input can contain either a character or command. A character can be any standard ASCII printable character such as a letter, number, or punctuation mark. Commands include several ASCII control characters, such as line feed, carriage return, tab, and backspace. In addition, the cursor can be placed anywhere on the screen, turned on and off, and displayed as a blinking or solid underscore or block. Refer to Table 2 for a complete mapping of the input data.

To generate a composite video signal, video synchronization (sync) pulses and picture data are needed. The ATmega8's internal 16-bit timer is used to generate interrupts every 63.5 µs. An interrupt service routine is used to provide the necessary sync pulses via a digital I/O port. The picture data is generated by matching the character data from the internal RAM with the appropriate font data in program memory. The font data is written to a shift register though eight digital I/O ports and the resulting serial data stream is combined

Figure 1



with the sync pulses to generate the display.

In order to generate a stable picture, the timing of the sync pulses must be exactly the same for each line. Being even one clock cycle off will cause a distorted picture. On the ATmega8, like most CPUs, an interrupt is not serviced until the current instruction is finished executing. Since some instructions take more cycles than others to complete, the interrupt response times vary.

To overcome this, the system timer actually generates two interrupts. The first interrupt occurs just prior to the timer reaching 63.5 µs. System variables are saved and the CPU is placed into sleep mode. Shortly afterward, at exactly 63.5 µs, the second interrupt calls the sync generation code. This method ensures that the interrupt response time is exactly the same and the sync pulses are identical.

Normal TV signals are interlaced pictures that use 525 scan lines per frame, refreshed 30 times per second. This display generates a non-interlaced picture. This format increases the refresh rate to 60 times per second, but uses only 262 scan lines per frame. This leaves a small blank space between each line. On smaller TVs, this is not noticeable; however, on larger TVs (25" and up), something similar to the display in Figure 3 might be observed.

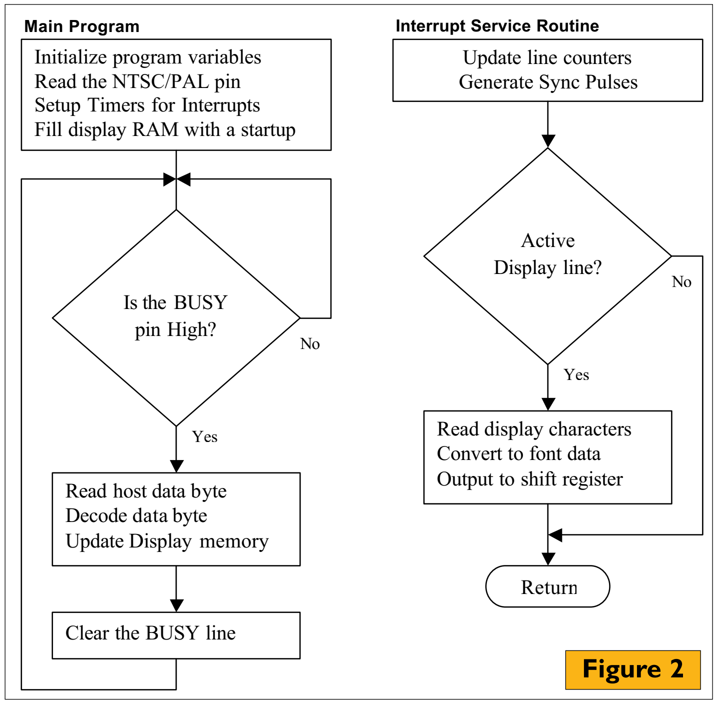


Figure 2

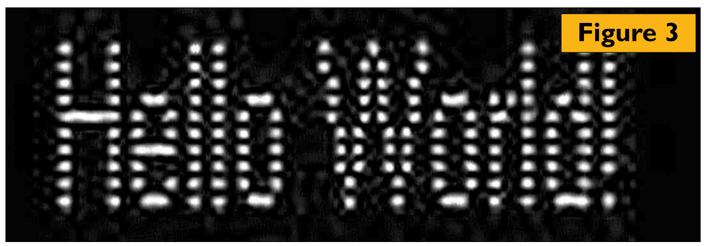


Figure 3

About the Circuit

Now, let's take a look at the schematic (Figure 4). The input port (J1) is connected to a 74HC573 octal latch (IC2). This holds the host's input until the ATmega8 (IC1) can process it. The 74HC74 dual D flip-flop (IC4) has two functions. One flip-flop acts as the strobe latch and busy flag. It ensures that the host's strobes are not missed by the ATMega8 during screen refresh. The second flip-flop divides the system's 16 MHz clock in half to provide the proper shift rate (dot clock) to the shift register. The 74HC165 shift register (IC3) takes the parallel font data and shifts it out to the analog section. The analog section

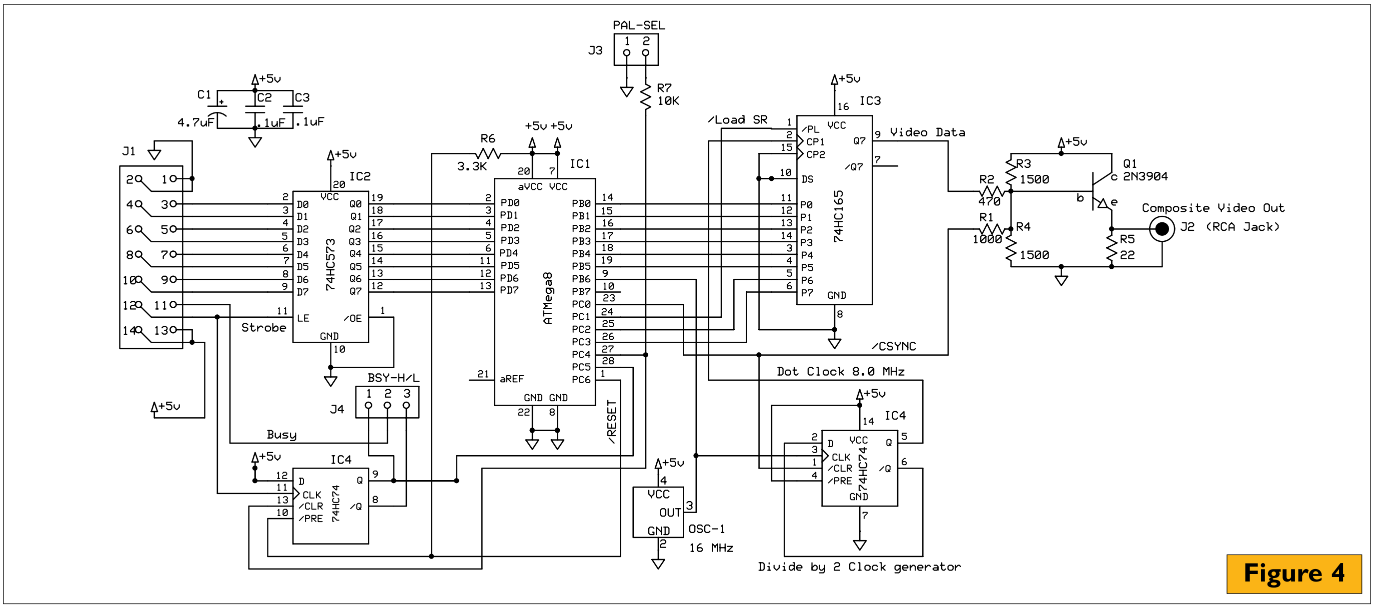


Figure 4

is a simple digital-to-analog converter that provides the necessary composite video voltage levels.

The 74HC573 eight-bit latch was included to reduce the time required by the host to keep the eight-bit data valid. If your host can keep the input valid during the entire "busy" state of the display, then the latch can be eliminated. Figure 5 shows the timing diagram for the host interface.

There are two optional jumpers in the circuit. J3 selects the video standard. It is left open for NTSC and shorted for PAL. J4 selects the busy output's logic level. Short pins 1-2 for active high or pins 2-3 for active low.

A complete list of parts is given in Table 1. Because of the small parts count, construction can be completed on a small perfboard. A pre-programmed ATmega8 controller and an etched printed circuit board measuring 2.5" x 1.9" (Figure 6) are available from the author. The Intel-Hex object file needed to program your own ATmega8 controller is also available from the *Nuts & Volts* FTP library (**www.nutsvolts.com**).

Using the Display

The circuit can be connected to any device capable of producing the eight-bit data and an active high strobe. The busy line should be monitored to ensure the previous command has completed. This is especially true during scrolling operations, as it can take several milliseconds to scroll the entire screen. If the busy line cannot be monitored, then wait at least 25 milliseconds between characters to prevent data loss.

A simple circuit to test your display is shown in Figure 7. Set the switches for the desired binary code and press the Strobe button. The busy LED will light while the command is processing and the display will change. However, since the display circuit is running at 16 MHz, the LED won't be lit long enough to be seen!

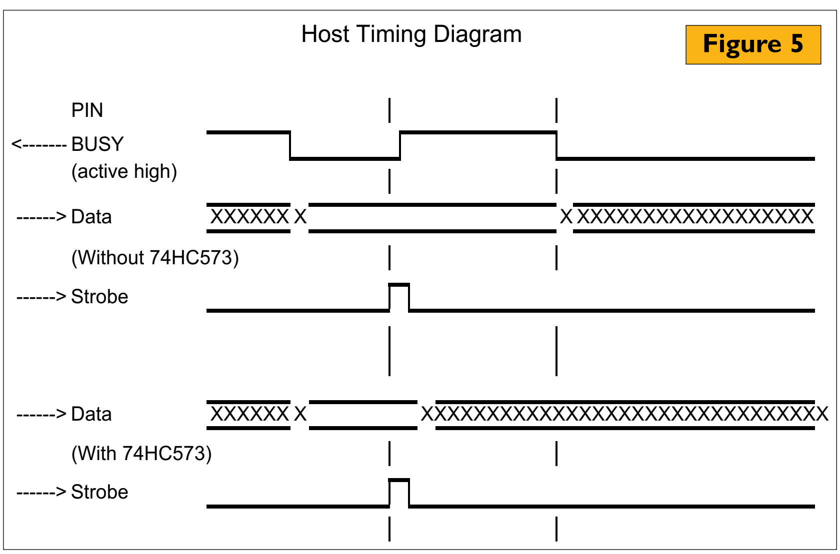


Figure 5

After power up, the system initializes itself and displays a startup banner. The initial state has the Primary font selected, lower 128 character mode enabled, and a blinking underscore cursor. To clear the screen, send a Form Feed control character — $0C (hexadecimal notation) — to the display. The screen will clear and the cursor will move to the upper left corner.

A picture of both fonts is shown in Figure 8. The lower 128 input bytes for both fonts represent the standard ASCII character set. This allows the display to emulate a simple terminal without special encoding from the host. To allow for maximum control, the upper 128 bytes are used for cursor movement, scrolling, and mode changes.

Part	Description	Digi-Key Part #
IC1	ATmega8 microcontroller	ATMEGA-16PC-ND
IC2	74HC573 octal latch	TC74HC573AP-ND
IC3	74HC165 shift register	MM74HC165N-ND
IC4	75HC74 dual D flip-flop	MM74HC74AN-ND
OSC-1	16.0 MHz TTL oscillator	CTX196-ND
Q1	2N3904 NPN transistor	2N3904FS-ND
R1	1,000 Ω resistor	1.0KQBK-ND
R2	470 Ω resistor	470QBK-ND
R3, R4	1.5K Ω resistor	1.5KQBK-ND
R5	22 Ω resistor	22QBK-ND
R6	3.3K Ω resistor	3.3KQBK-ND
R7	10K Ω resistor	10KQBK-ND
C1	4.7 µF electrolytic cap.	P973-ND
C2, C3	0.1 µF bypass capacitor	399-2155-ND
J1	14 pin header (7x2x.1)	103186-7-ND
J2	RCA video jack	CP-1403-ND
J3	Two pin header (1x2x.1)	103185-2-ND
J4	Three pin header (1x3x.1)	103185-3-ND

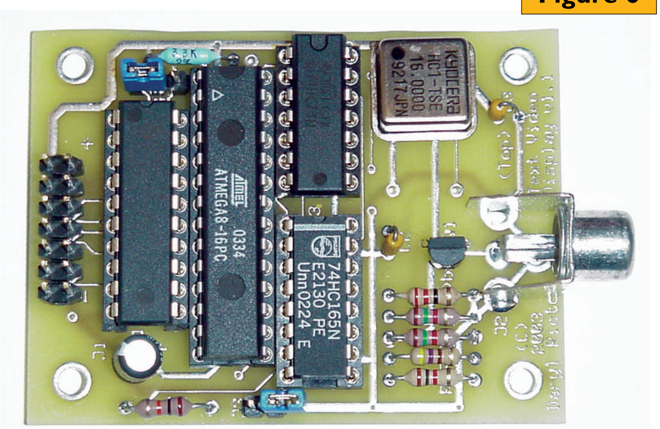
Note: All parts are available online from **www.digikey.com** A preprogrammed ATmega8 controller ($9.99) and an etched PCB ($19.99) are available from the author. Contact him via Email: 65c02@softcom.net

Table 1. **Parts List**

These commands are always "mapped in" and available, regardless of font or mode selection (see Table 2).

The primary font is enabled by using code $F2. The extended ASCII characters can be printed by enabling the Upper 128 mode ($F1). When the Upper 128 mode is enabled, sending bytes from $00-$7F will generate the corresponding graphics characters. Enabling the Lower 128 mode ($F0) will restore the standard ASCII characters. Since the first 32 bytes of the ASCII standard are non-printed control codes, some extra graphical characters

Figure 6



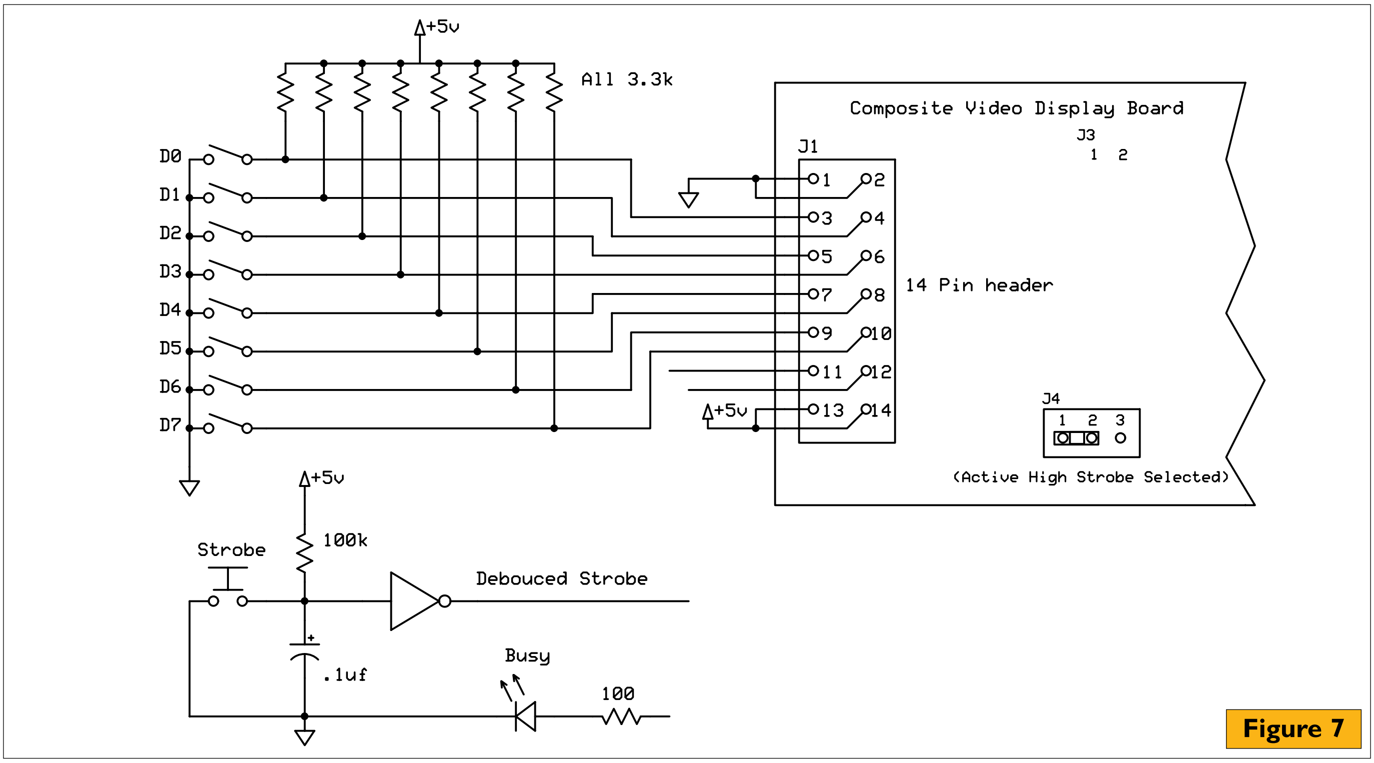


Figure 7

have been added to their font spaces ($00-$1F). These characters are accessed by sending bytes $80-$9F. Please note, however, that this remapping is only active while in the Lower 128 mode.

The alternate font is enabled by using code $F3 and works in a slightly different way. The Upper 128 mode prints the inverse (black on white) of the Lower 128 mode characters. In other words, think of the Lower 128 ($F0) code as normal mode and the Upper 128 ($F1) code as inverse video mode. The extra graphic characters accessed using $80-$9F work the same. They appear normal in Lower 128 mode and inverse in Upper 128 mode.

Commands include six ASCII control characters: Backspace ($08), Tab ($09), Line Feed ($0A), Form Feed ($0C), Carriage Return ($0D), and Delete ($7F). There are four scrolling commands, allowing the entire display to be moved up ($EC), down ($ED), left ($EE), or right ($EF). Other commands allow the cursor to be moved up ($E8), down ($E9), left ($EA), and right ($EB) one space or move HOME ($BA) without erasing the screen. The cursor can be turned off ($BB), turned on as an underscore ($BC), turned on as a block ($BD), set to blink ($BE), and set to not blink ($BF).

That's all there is to it. Its rich assortment of built-in resources and its processing power allow the ATmega8 microcontroller to make easy work of generating a text display. Why not try it in your next project? **NV**

Figure 8

Author Bio

Daryl Rictor is an electronics technician with more than 19 years of experience. He currently works as a voice and data communications specialist. He has an A.S. in Electronics Systems Technology from the Community College of the Air Force. His hobbies include single-board computer design, firmware and software applications development, and experimenting with digital I/O techniques.

ASCII Code	Function
00 - 07	Null
08	Backspace (destructive)
09	TAB (stops are 0, 8, 16, 24, 32)
0A	Line feed
0B	Null
0C	Form feed (Clear the screen and move cursor to top left)
0D	Carriage return (Clears rest of line)
0E - 1F	Null
20 - 7E	Standard printable ASCII characters in 8 x 8 font
7F	Delete (clear character @ cursor, does not shift rest of line left)
80 - 9F	Print the 32 special purpose characters (from font positions 0-31)
A0 - B8	Move cursor directly to Row 0-24, respectively
B9	Null
BA	Cursor home — move cursor to top left without clear
BB	Turn cursor off (hide it)
BC	Turn on block cursor
BD	Turn on underscore cursor
BE	Set cursor to blink mode (blink rate is approximately .5 second on, .5 second off)
BF	Set cursor to solid mode (no blink)
C0 - E7	Move cursor directly to column 0-39, respectively
E8	Move cursor up one row (no scrolling)
E9	Move cursor down one row (no scrolling)
EA	Move cursor left one column (no scrolling)
EB	Move cursor right one column (no scrolling)
EC	Scroll screen up on row (bottom is filled in with spaces)
ED	Scroll screen down on row (top is filled in with spaces)
EE	Scroll screen left one column (right column is filled in with spaces)
EF	Scroll screen right one column (left column is filled in with spaces)
F0	Select the lower 128 characters (including supported control characters)
F1	Select the upper 128 characters (including box drawing set or inverse video)
F2	Set font to Primary-256 DOS character set
F3	Set font to Alternate-128 characters with inverse video support
F2 - FF	Null (reserved for expansion)

Table 2. **Character/Command Reference**

Electronics Showcase

Special products and services for the electronics enthusiast.

Circle #75 on the Reader Service Card.

Pick the Network Protocol that's Right for your Device

Options for Communicating in Local Networks and on the Internet

by Jan Axelson

If you have a device that you want to use in a local network or on the Internet, one of the decisions you'll need to make is how the device will exchange information with other computers in the network. Many devices host web pages that display information and enable users to send input, but web pages aren't the only option.
Other choices include Email, File Transfer Protocol (FTP), and custom applications that use lower level Internet and Ethernet protocols.
This article explores the possibilities, including how to decide which option is best for your project. The focus is on solutions that are practical for small systems, but the information also applies to PCs that perform monitoring and control functions in networks.

If you have a project that involves putting a device on a local network or the Internet, one decision you'll need to make is how the device will exchange information on the network. Even for small devices, there are more options than you might think.

A device can host web pages, exchange Email and files, and run custom applications that use lower level Ethernet and Internet protocols.

This article will help you decide which protocol or protocols best suit your application. The focus is on options that are practical for small systems, but the information also applies to PCs that perform monitoring and control functions in networks.

The Basics of Networking Protocols

Computers can use a variety of protocols to exchange information on a network. Each protocol defines a set of rules to perform a portion of the job of getting a message from one computer to the program code that will use the message on the destination computer. For example, the Ethernet protocol defines (among other things) how a computer decides when it's okay to transmit on the network and how to decide whether to accept or ignore a received Ethernet frame.

Other protocols can work along with the Ethernet to make transmissions more efficient and reliable, to enable communications to travel beyond local networks, and to provide information that a specific application requires. For example, every communication on the Internet uses the Internet Protocol (IP) to specify a destination address. Table 1 shows protocols that many small systems support.

Multiple networking protocols work together by communicating in a layered structure called a *stack*. The lowest layer is the Ethernet controller or other hardware that connects to the network. The top layer is the end application, such as a web server that responds to requests for web pages or a program that sends and requests Email messages.

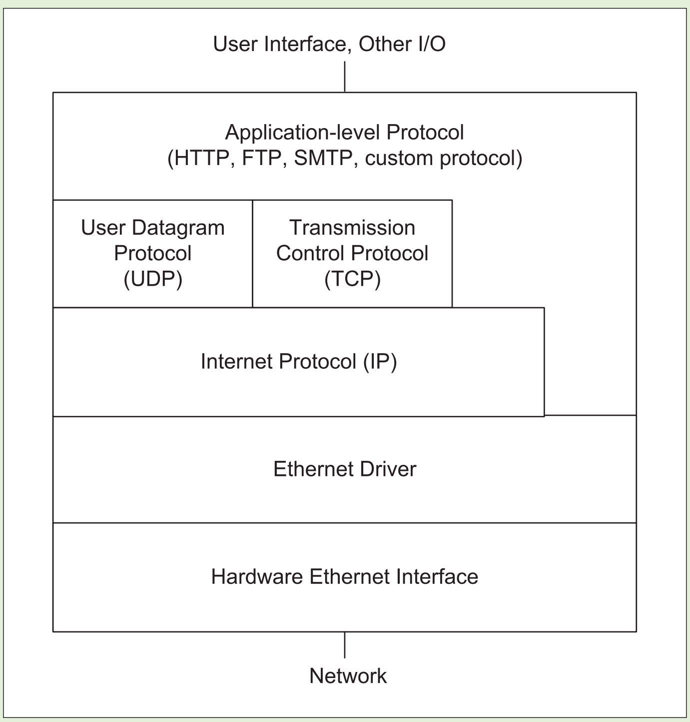
Figure 1 shows typical layers in a networking stack. Not every computer needs to support every protocol. Small devices can conserve resources by supporting only what they need.

The program code (or hardware) that makes up each layer has a defined responsibility. Each layer also knows how to exchange information with the layers directly above and below it, but a layer

Protocol	Use
Ethernet	Communicating in a local network.
Internet Protocol (IP)	Communicating on the Internet.
User Datagram Protocol (UDP)	Specifying a destination port for a message, (optional) error-checking.
Transmission Control Protocol	Specifying a destination port for a message, flow control, error checking.
Hypertext Transfer Protocol (HTTP)	Requesting and sending web pages.
Post Office Protocol 3 (POP3)	Requesting Email messages.
Simple Mail Transfer Protocol (SMTP)	Sending Email messages.
File Transfer Protocol (FTP)	Exchanging files.

Table 1. Small devices can use many of the same protocols that larger systems use.

Figure 1. Network programming uses a series of layers, with each layer handling part of the job of getting a message to its destination.



doesn't have to know anything else about how the other layers do their jobs.

In transmitting, a message travels down the stack from the application layer that creates the message to the network interface that places the message on the network. In receiving, the message travels up the stack from the network interface to the application layer that uses the data in the received message.

The number of layers a message passes through can vary. Within a local network, an application layer may communicate directly with the Ethernet driver. Messages that travel on the Internet must use the Internet Protocol (IP). Messages that use IP can also use the User Datagram Protocol (UDP) or the Transmission Control Protocol (TCP) to add features, such as error checking and flow control.

Vendors of development boards with networking abilities often provide libraries or classes to support popular protocols. This support greatly simplifies how much programming you need to do to get something up and running.

Just Ethernet

To communicate over a local Ethernet network, the minimum requirement is program code that knows how to talk with the Ethernet controller. In most cases, the controller is a dedicated chip that interfaces to the network hardware and to the device's CPU. The controller chip handles much of the work of sending and receiving Ethernet communications.

To send a message, the device's program code (often called *firmware* in small devices) typically passes the data to be sent and a destination address to the controller. The controller places the information in the expected format, adds an error-checking value, sends the message on the network, and makes a status code available to let the CPU know if the transmission succeeded.

In receiving a message, the controller checks the destination address and performs error checking. If the address is a match and no errors are detected, the controller stores the message and uses an interrupt or flag to announce that a message has arrived.

For applications that don't need much more than Ethernet support, a good resource is the interface boards and program code from EDTP Electronics. EDTP's Packet Whacker (Figure 2) contains an Ethernet controller, an RJ-45 connector for an Ethernet cable, and a parallel interface for connecting to a microcontroller. Example code for Microchip's PICMicros and Atmel's AVR microcontrollers is available.

See Peter Best's "Easy Ethernet Controller" in the January 2004 *Nuts & Volts* for more about using the Packet Whacker. Fred Eady's new book, *Networking and Internetworking with Microcontrollers* (Newnes), has the most detailed explanation around regarding accessing Ethernet controllers in small systems.

Using Low-level Internet Protocols

A device that communicates on the Internet must support Internet protocols. Devices in local networks often use Internet protocols, as well, because they add useful capabilities and have wide support.

The essential protocol for Internet communications is IP, which defines the addressing system that identifies computers on the Internet. Each IP datagram includes addressing information, information for use in routing the datagram,

and a data portion that contains the message that the source wants to transmit to the destination. In a local network, an IP datagram can travel in the data field of an Ethernet frame.

Many Internet communications also use TCP. An important feature of TCP is support for the handshaking that enables the sender to verify that the destination has received a message. TCP also enables the sending computer to provide an error-checking value for the message and to name a port that will receive the message on the destination computer. Applications that don't require TCP's handshaking may use UDP — a simpler protocol that can be useful for systems with limited resources.

A TCP segment or UDP datagram travels in the data portion of an IP datagram. The data area of the TCP segment or UDP datagram contains the message the source wants to pass to the destination.

To use a PC to communicate with a device that uses TCP or UDP, you can use just about any programming language. In Visual Basic .NET, you can use the System.Net.Sockets namespace or the UdpClient or TcpClient classes. Listing 1 shows some example code for TCP communications. Visual Basic 6 supports TCP and

The Internet Protocol Gets an Upgrade

For a couple of decades, Version 4 of Internet Protocol (IPv4) has been the workhorse that has helped get messages to their destinations on the Internet, but Version 6 (IPv6) is now making its way into networking components and will eventually replace IPv4. Probably the biggest motivation for change was the need for more IP addresses, but IPv6 has other useful enhancements, as well, including support for auto-configuring, the ability to request real time data transfers, and improved security options.

Where to Find IPv6

In the world of desktop computers, recent versions of Windows, OS X, and Linux all support IPv6. For microcontrollers, Dallas Semiconductor's runtime environment for TINI modules supports IPv6 addressing.

If you don't need IPv6's benefits, upgrading isn't likely to be required any time soon. For the near future, routers that support IPv6 will continue to support IPv4, converting between protocols as needed.

Increasing the Address Space

IPv6 vastly increases the number of IP addresses available to computers on the Internet.

An IPv4 address is 32 bits. IPv6 addresses are 128 bits, allowing over 300,000,000,000,000,000,000,000 (that's 300 sextillion) values. Using this many bits may seem like overkill, bit IPv6's creators wanted to be very, very sure that the Internet wouldn't run out of addresses for a very long time. Having plenty of bits to work with also makes it easier to create routing domains, which enable a router to store a value that indicates where to send traffic destined for addresses in a defined group. Routing domains allow simpler routing tables and more efficient traffic routing.

An IPv4 address is usually expressed as four decimal numbers separated by periods:

192.168.111.1

Each decimal number represents one of the four bytes in the address.

IPv6 addresses are written as 16-bit hexadecimal values, separated by colons. The IPv4 address above translates to this:

0:0:0:0:C0:A8:6F:1

A double colon can replace a series of 16-bit zero values:

::C0:A8:6F:1

(An address can have no more than one double colon.)

It's also acceptable to express an IPv4 address converted to IPv6 using decimal values instead of hexadecimal:

::192.168.111.1

Other Benefits

Even if you don't need IPv6's addressing, other additions to the protocol can make a switch worthwhile.

Stateless Autoconfiguration frees users and administrators from having to enter IP addresses manually. A computer can generate its own IP address and discover the address of a router without requiring a human to enter the information or requiring the computer to request the information from a server.

Autoconfiguring is especially handy for mobile devices that move around, possibly connecting to a different network each time the device powers up.

IPv6 also adds security features. Two new headers are the Authentication header and the Encapsulating Security Payload (ESP) header. The Authentication header enables a computer to verify who sent a packet, find out if data was modified in transit, and protect against replay attacks, where a hacker gains access to a system by capturing and resending packets. The ESP header and trailer provide security for the data payload, including support for encryption.

Every IPv6 header also includes a Flow Label that can help real time data get to its destination on time. A value in the Flow Label can indicate that a packet is one in a sequence of packets traveling between a source and destination. A source can request priority or other special handling for packets in a flow as they pass through intermediate routers. To find out more about IPv6, some good sources are:

Internet Protocol, Version 6 (IPv6) Specification
The document that defines IPv6.
ftp://ftp.rfc-editor.org/in-notes/rfc2460.txt

IPv6 Forum
Information and links.
www.ipv6forum.com/

IP Version 6 (IPv6)
An introduction to IPv6 and many links.
playground.sun.com/pub/ipng/html/ipng-main.html

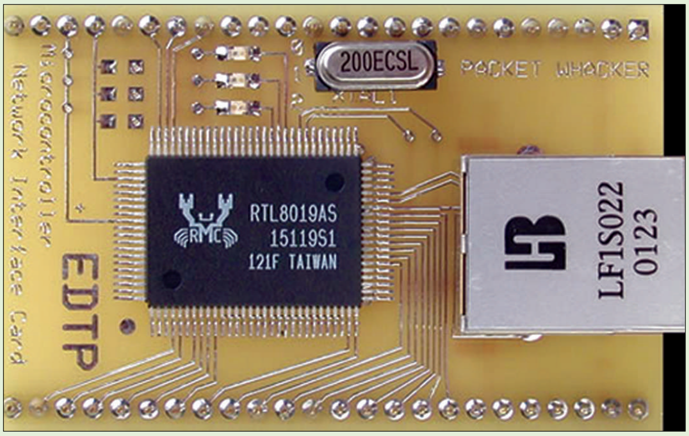


Figure 2. Use the Packet Whacker to add Ethernet to just about any CPU with a parallel interface.

UDP communications via the Winsock control.

Serving Interactive Web Pages

One of the most popular ways for computers to share information in networks is via web pages. Many web pages are static, unchanging displays of information, but small devices usually want to serve pages that display real time information or receive and act on user input.

My article, "Control Your Devices from a Web Page," in the March 2004 *Nuts & Volts* showed one example. I used a Dallas Semiconductor TINI module to serve a page that enables users to monitor and control the device.

Requests for web pages use the Hypertext Transfer Protocol (HTTP). The requests and the responses containing the web pages travel in TCP segments. To serve web pages, a device must support TCP and IP and must know how to respond to received requests.

For creating web pages that display real time data and respond to user input, there are several options.

Devices programmed in C often use the Server Side Include (SSI) and Common Gateway Interface (CGI) protocols. Rabbit Semiconductor's Dynamic C for its RabbitCore modules supports both.

Devices programmed in Java can use a servlet engine that enables running Java servlets, which extend a server's abilities. Two servlet engines for TINIs and other small systems are the Tynamo from Shawn Silverman and TiniHttpServer from Smart SC Consulting.

A third option is to use a product-specific protocol that defines how a device can insert real time data into web pages and receive user input. Netmedia's SitePlayer and Redpoint Controls' Red-i BASIC Stamp Web Server are examples of this approach.

Exchanging Messages via Email

Email is another option that small devices can use to communicate in networks. Email's original purpose, of course, was to enable humans to exchange messages, but devices can also be programmed to send and receive messages without human intervention.

Just like a person, a device can have its own Email account, user name, and password. The device firmware can compose messages to send and process received messages to extract the information inside.

For example, a security system can send a message when an alarm condition occurs or a device can receive configuration commands in an Email message.

With Email, the sender can send a message whenever it wants and recipients can retrieve and read their messages whenever they want. The downside is that recipients may not get information as quickly as needed if they don't check their Email or if a server backs up and delays delivery.

To send and receive Emails on the Internet, a device must have an Internet connection, an Email account that provides access to incoming and outgoing mail servers, and support for TCP/IP and the protocols used by the mail servers to send and retrieve Email. Two protocols suitable for small systems are the Simple Mail Transfer Protocol (SMTP) for sending Email and the Post Office Protocol Version 3 (POP3) for retrieving Email.

Exchanging Files with FTP

Devices that store information in files can use FTP to exchange files with remote computers. Every FTP communication is between a server — which stores files and responds to commands from remote computers — and a client — which sends commands that request to send or receive files. A device may function as either a server or client.

To use FTP, a device must support a file system where blocks of information are stored in named entities called files. In

Resources

Dallas Semiconductor
TINI modules.
www.dalsemi.com

EDTP Electronics
Packet Whacker Ethernet board.
www.edtp.com

Embedded Ethernet and Internet Central Links to sources for modules and code.
www.Lvr.com/ethernet.htm

Netmedia
SitePlayer Web Server.
www.siteplayer.com

Rabbit Semiconductor
RabbitCore modules and Dynamic C.
www.rabbitsemiconductor.com

Redpoint Controls
Red-i BASIC Stamp Web Server.
www.redpointcontrols.com

Smart SC Consulting
TiniHttpServer web server and Java servlet engine.
www.smartsc.com

Tynamo
Web server and Java servlet engine.
tynamo.qindesign.com

a small device, a file system can be as basic as a structure whose members each store a file name, a starting address in memory, and the length of the file stored at that address.

FTP communications travel in TCP segments. A device that supports FTP must also support TCP and IP.

Moving On

For more information and ideas about network applications for small systems, a good place to start is my website's Embedded Ethernet and Internet Central page (**www.Lvr.com/ethernet.htm**), which has code examples and links to sources for modules with networking support. **NV**

About the Author

Jan Axelson is the author of *Embedded Ethernet and Internet Complete, USB Complete,* and other books about computer interfacing. Jan's website is **www.Lvr.com**

Listing 1. In Visual Basic .NET, you can use the TcpClient class to communicate with your devices.

```
' Read data from a remote computer over a TCP connection.
Dim networkStream As networkStream =
myTcpClient.GetStream()

If networkStream.CanRead Then

  Dim dataReceived(myTcpClient.ReceiveBufferSize) As Byte

  ' Read the networkStream object into a byte buffer.
  ' Read can return anything from 0 to numBytesToRead.
  ' This method blocks until at least one byte is read
  ' or a receive timeout.
  Dim numberOfBytesRead As Integer = networkStream.Read _
        (dataReceived,
        0,
        CInt(myTcpClient.ReceiveBufferSize))
Else
   MessageBox.Show("You can't read data from this
stream.")
   Return
End If


' Write data to a remote computer over a TCP connection.
Dim networkStream As networkStream =
myTcpClient.GetStream()
Dim dataToSend(7) As Byte

' (Place data to send in the byte array.)

If networkStream.CanWrite Then
  networkStream.Write _
       (dataToSend,
       0,
       dataToSend.Length)
Else
  MessageBox.Show("You can't write data to this stream.")
End If
```

A Really Solderless Breadboard Part 2

by Al Williams

Last month, I showed you how easy it is to build logic circuits using a Xilinx CPLD (Complex Programmable Logic Device). This month, we'll dig into a more sophisticated design. In particular, I'll show you how to build a useful piece of test equipment — a "logic scope." This is a poor man's logic analyzer. The logic scope reads four bits of digital data, records them, and then displays the waveforms on a normal oscilloscope (Figure 1).

This would be a formidable project if we were using discrete gates and components. Of course, you could use a microprocessor; however, it is difficult to make a microprocessor sample at varying clock rates. Also, the microprocessor must be able to clock much faster than the incoming sample clock. Not only do you have to observe the Nyquist limit, but you also have to have time to execute many instructions before the next clock arrives.

The CPLD, on the other hand, can do all required operations together on each clock. There aren't any steps like those required by a microprocessor. With the logic scope I've designed, you can feed in an external clock from the system you are testing or an asynchronous clock to make periodic measurements.

You can build the logic scope using the same hardware you used for last month's adder project. That's the beauty of a CPLD — you can reconfigure it to do different tasks. I used the PBX-84 prototype board (Figure 2) to build the circuit on a solderless breadboard. The only unusual circuitry you need for the scope is a simple DAC, made with common resistors (Figure 3). You can get fancy and add some DIP switches and, except for the sake of prototyping, you can use breadboard wires for the switches.

In addition to the five inputs (four data lines and a clock), the scope also requires a four-bit trigger input and a four-bit mask input. The logic adds the mask with the incoming signal and compares it to the trigger. If there is a match, the device starts storing data until its small memory is full, then holds the buffer until the device is reset.

The connection to the oscilloscope requires four outputs. Three outputs drive the DAC. You can think of the two most significant bits as a "channel select," since it sets the base level of the DAC for each of the four channels. The least significant bit shows the state of the channel (either 1 or 0). If you were to look at the output normally, you'd see a staircase effect. To the left of the screen would be channel 0, with channel 1 above and to the right, followed by channel 2 a little higher and even further to the right. Finally, channel 3 would be all the way to the right and above all of the other signals.

That wouldn't be very useful, so the final logic scope output provides a trigger that resets the scope trace for each channel. Since the phosphor on the scope doesn't go dark immediately and your eye retains the light, you get the illusion of having four channels on a single scope probe. Needless to say, PC-based or other scopes that don't work like a traditional scope won't work for this application. However, even a simple, one channel scope will work, as long as it supports external triggering. If you have a two channel scope, you can either trigger it externally or on the second channel.

About Synchronous Logic

Unlike last month's project, the logic scope has a wealth of flip flops and subassemblies made of flip flops. Flip flops use a clock and allow you to store data for later use. Using clocked — or synchronous — logic also allows you to avoid complex race conditions that are common when trying to design asynchronous logic.

The basic type of flip flop is an SR (Set Reset) flip flop. When you make the S input true, the output goes true and stays true, even if the S input goes false. The output (conventionally called Q) goes false when the R input is true and remains false until another event on the S input occurs.

Of course, this presupposes that the S

Figure 1. The logic scope in action.

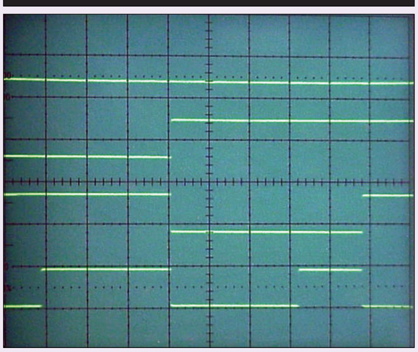
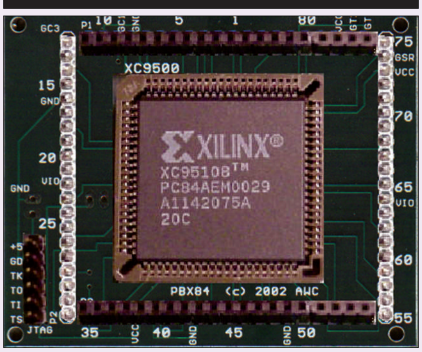


Figure 2. The PBX-84 board.



and R inputs won't be true at the same time. Another type of flip flop, —the JK — acts like an SR flip flop, but Q toggles if both inputs are true.

Sometimes, you want a flip flop that only toggles. For example, you might want to push a button once to enable a device (Q = true) and again to disable it (Q = false). You'll usually use a T flip flop for this type of circuit.

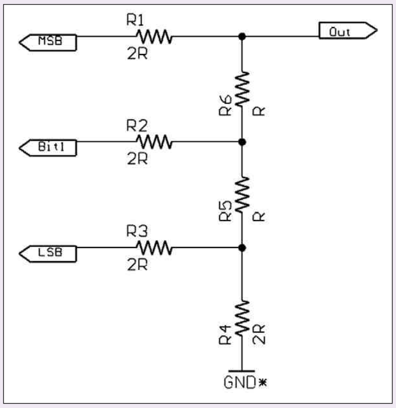


Figure 3. The DAC.

The final type of flip flop you'll commonly encounter is the D flip flop. This type of flip flop makes Q equal to the D input and holds that state. The advantage of clocked logic is that the flip flops only examine their inputs when they detect a clock edge. Even though different parts of the circuit might require different amounts of time to generate correct outputs, it will all work as long as no part requires more time than it takes to generate the next clock pulse.

This means, however, that it is vital for all flip flops to see the clock signal at the same time. If one flip flop sees the clock 100 nS before another flip flop, an incorrect operation may result (this is known as clock skew). To minimize this problem, CPLDs have unique clock pins that use special techniques to minimize skew. All of the flip flop clocks connect to one central clock.

This means you should avoid things like ripple counters, where one flip flop's Q output feeds another flip flop's clock. It is better to run everything off a single clock and use clock enable pins to enable or disable the clock, as necessary. For example, Figure 4 shows a simple, two bit ripple counter. Figure 5 shows how you can change this design to use a single clock. With this scheme, both flip flops get the same clock signal, but the lower flip flop only changes when the upper flip flop's Q is high.

It is very important to understand the components you'll use in a CPLD design. The Xilinx documentation discusses each block. Resets and presets require special attention. Sometimes they are synchronous and sometimes they are asynchronous. A synchronous reset has no effect if it occurs in between active clocks; however, an asynchronous reset will clear the output immediately. The chip has special global signals for resets, just as it does for clocks.

The Logic Scope

Figure 6 shows a block diagram of the logic scope. It has four major subsystems: *Counter, Triggering, Storage,* and *Output.*

The counter stage is a five-bit counter. It provides an address to the storage subsystem (three bits), plus an additional two bits to provide a channel to the output

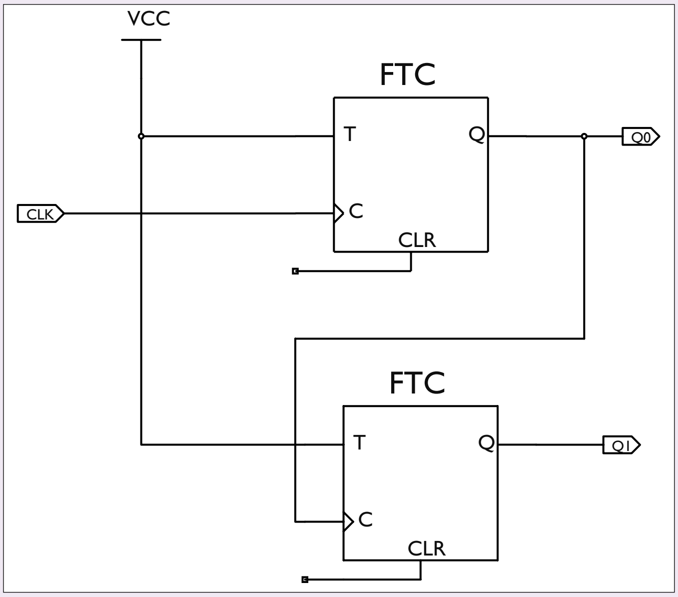


Figure 4. A simple two-bit counter with ripple clock.

subsystem. This allows the storage system to cycle through a complete channel (seven samples), then repeat the cycle for the other three channels in sequence.

The triggering stage compares the input data to a mask and trigger key, as described earlier. When a match is found

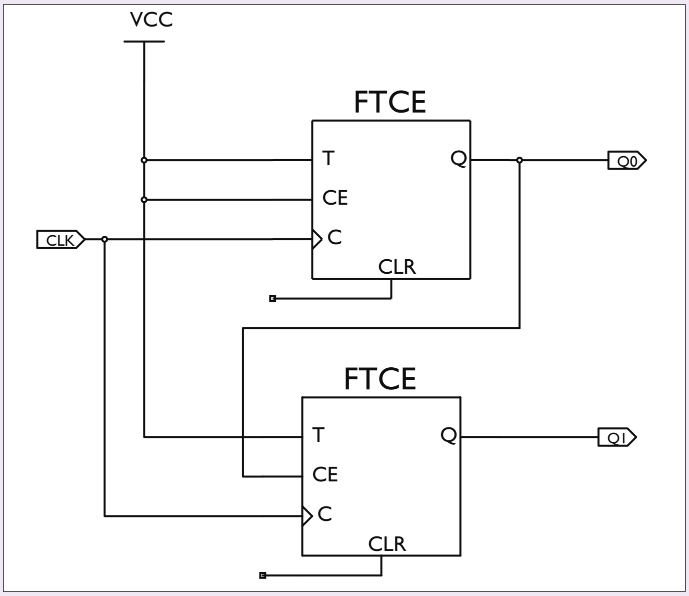


Figure 5. A two-bit counter that uses clock enable.

and there is no previous trigger, the stage triggers the device. This resets the counter to zero and starts storing input data.

The storage system is simply a four bit by eight location RAM. Some CPLDs and FPGAs have RAM built into them, but the XC9500 does not. Still, it is easy to make RAM from spare flip flops. Another flip flop is set when the unit triggers and is reset when the counter wraps around. This flip flop controls the writing of the memory. Therefore, the unit will only store input data during the first cycle after triggering. On subsequent cycles, the RAM only recalls its data.

The output system feeds the off chip DAC. It simply selects one bit from the storage system and outputs it to the least significant bit of the DAC. The two most significant bits are from the counter.

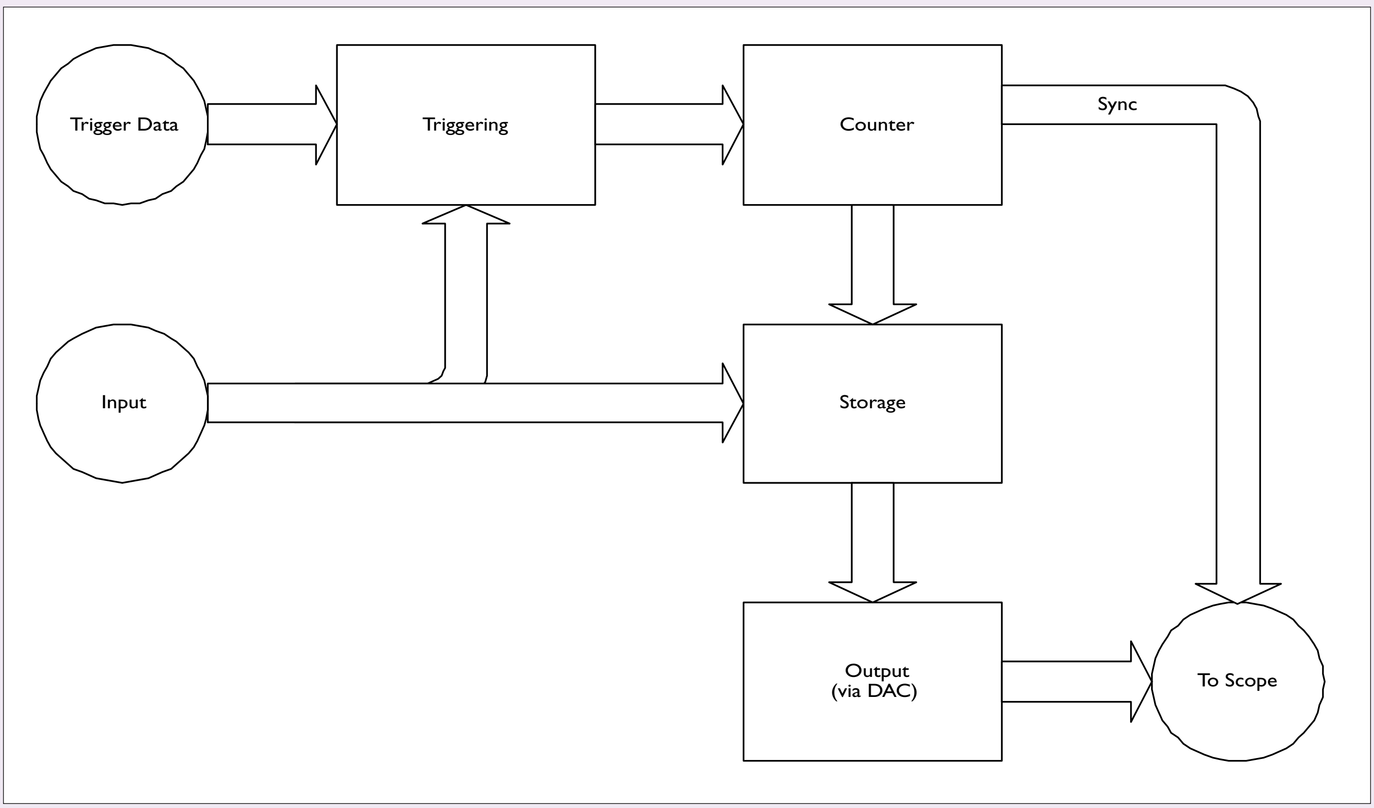
The DAC, incidentally, isn't very critical. I used all 22K resistors. The 11K resistors are actually two 22K resistors in parallel. The resistor network depends on the ratio of 2:1 resistance. The actual values are not that important, as long as the resistance isn't so low that the CPLD has trouble driving the DAC.

Implementation

You can see the top-level schematic for the scope in Figure 7. Notice that the RAM and the counter are both Verilog modules. The MASKCOMP module is another schematic (Figure 8). The M4_1E, FDRS and FD components are all standard components from the Xilinx library. The SEL(1) signal connects to the MSB of the DAC and SEL(0) connects to the middle bit. The LSB output connects to the LSB input of the DAC.

You can probably guess that the count3 component corresponds to the counter subsystem and the RAM 4 x 16 module is the storage system. I originally stored 16 slots instead of eight and never changed the name. The M4_1E component is the output selector.

Figure 6. Block diagram of the Logic Scope.



The flip flops require a little explanation. The FDRS flip flop in the lower left corner controls the writing of the memory. The other FDRS flip flop controls the triggered state of the unit. Notice that there are a few low-level gates to get all the logic straight.

The FD flip flop provides a one clock cycle delay on the sync output. Without this, the scope would trigger before the counter resets to zero and incorrect data will show at the start of each sweep.

The MASKCOMP component is a good example of how to divide your circuit into subcircuits. It allows you to test each component separately and also makes higher level schematics easier to understand.

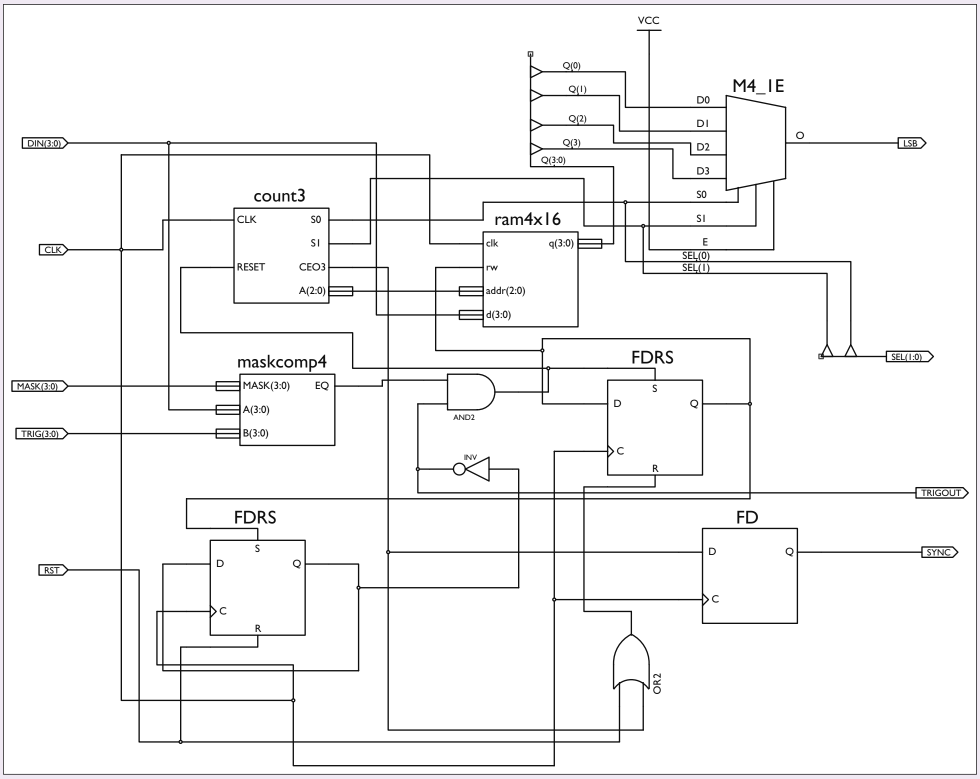


Figure 7. The top level schematic.

Sometimes using a schematic is cumbersome; for example, consider the count3 component. It is a five-bit counter with its outputs partitioned into a three-bit sample number and a two-bit channel number. Sure, you can model this counter with five flip flops, but the Verilog code is much simpler:

```
module count3(CLK,CEO3,A,S0,S1,RESET);
    input CLK;
    output [2:0] A;
        output S0;
        output S1;
        output CEO3;
    input RESET;
        reg [4:0] CT;

assign A=CT[2:0];
assign S0=CT[3];
assign S1=CT[4];
assign CEO3=((CT[2:0]==3'b111)?1'b1:1'b0);

initial
begin
  CT=0;
end

always @(posedge CLK)
begin
         if (RESET)
           CT<=5'b0;
         else begin
           CT<=CT+1;
               end
end
endmodule
```

The key to understanding this component is the always block. On each rising clock edge, the component increments the CT variable. The assign statements near the top set various outputs to the different parts of the variable. By using Verilog (or another HDL), it is easy to devise things, such as counters with a certain limit, large dividers, or anything that would require a large number of gates to represent in a schematic. Consider this Verilog that defines the storage RAM:

```
/* 4x8 RAM (was 4x16 RAM) */
module ram4x16(clk,rw,addr,d,q);
    input clk;
    input rw;
    input [2:0] addr;
    input [3:0] d;
    output [3:0] q;
    reg [3:0] mem [0:7];

assign q=mem[addr];

always @(posedge clk)
     if (rw) mem[addr]=d;
endmodule
```

This would be a substantial circuit to draw in the schematic editor. Even if you did draw it as a schematic, it would be tough to change the size, for example. In Verilog, it would be a matter of changing the array subscripts to make the RAM another size. In fact, you could use Verilog parameters so that the sizes could easily be set by changing a single parameter (like a C define) at the start of the module.

Verilog is a bit beyond the scope of this article; however, these two examples should show you that it is worth your time to learn it or a similar HDL. The Xilinx software provides HDL templates for many common constructs, as well.

After you've implemented the design, you can ask the Xilinx software for a timing report. This will tell you many

Online Resources

PBX-84 breadboard plus tutorials online:
www.al-williams.com/awce/pldhome.htm

Xilinx documentation and gate descriptions:
toolbox.xilinx.com/docsan/xilinx4/manuals.htm

Schematic for Xilinx JTAG cable:
toolbox.xilinx.com/docsan/2_1i/data/common/jtg/fig26.htm

The Xilinx home page:
www.xilinx.com

PBX-84 and related discussions:
groups.yahoo.com/group/awcpld

things, including the maximum clock frequency the design will support. According to the report, the scope will support clock rates up to 42.5 MHz. You could tweak different options in the software to try to push that frequency up, but you probably won't be able to push it much higher.

More Programmable Logic

By now, you should have a good reference as to how the logic scope works. In the online project files, you'll find that I made the scope a component. In the final chip, I added an eight-bit counter to serve as an external clock source. As a result, you can feed the chip an external clock or you can use a function generator or other oscillator to feed the divider and pick different clock frequencies by jumpering the output of the divider to the main clock input.

You can easily watch the output from a BASIC Stamp or other microcontroller to test the circuit. For simplicity, you might want to make the program generate its own clock. For example, here is a program for the BASIC Stamp II that would generate an appropriate test pattern:

```
clk con 4
I var byte
LOW clkpulse
DIRS=%0000000000011111
top:
FOR I=0 to 15
    OUTA=I
    PULSOUT clkpulse,10
NEXT
GOTO top
```

The output signal is on the Stamp's P0 to P3 pins and the clock is on P4. It would be easy to add more sample width or depth if you are using the 95108 CPLD.

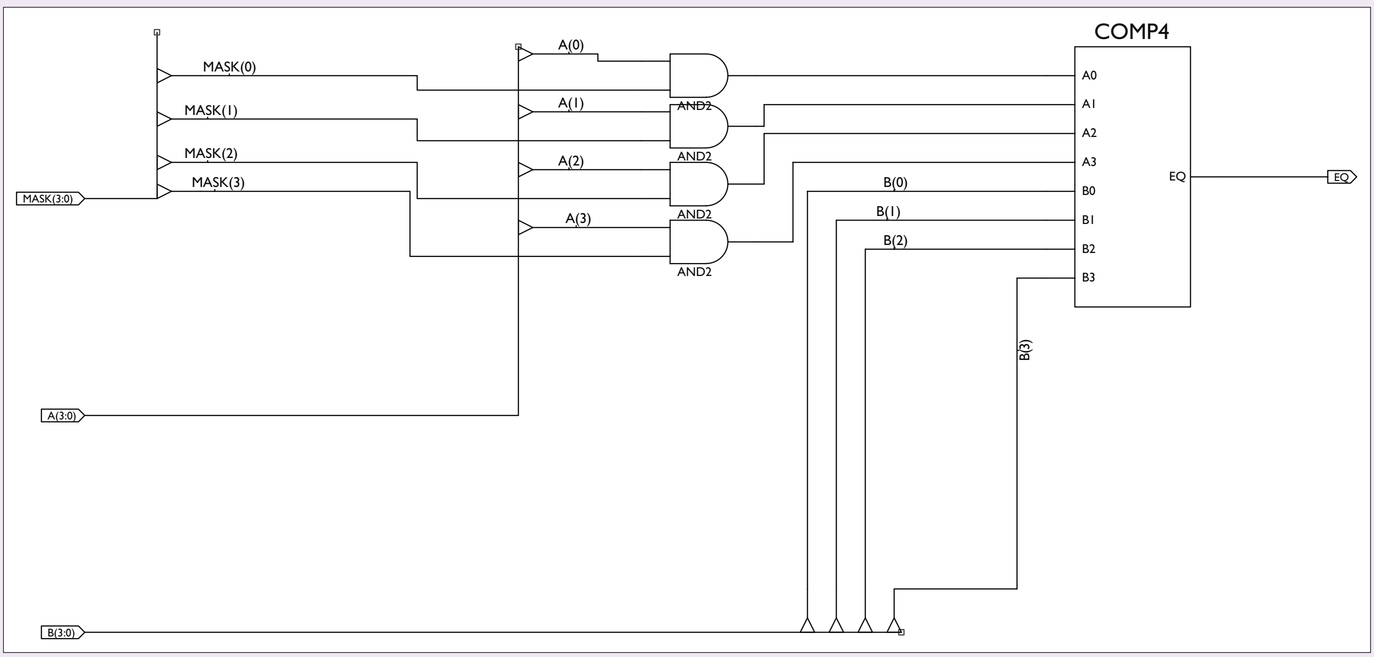
Naturally, there is much more to learn about programmable logic. Luckily, there are many resources on the web. Even though these articles have focused on CPLDs, you'll find that working with the larger FPGAs is fundamentally similar. Of course, most FPGAs require configuration on each power cycle (from a microcontroller, a PC or an external EEPROM). Also, FPGAs have much larger gate counts, RAM cells, and other special features. I have a board on my desk with a Xilinx Spartan IIE that has 200,000 logic gates inside! Still, even this chip uses the same software and the same techniques as I've shown you in this article.

There are many different logic circuits you could design with a CPLD. You can use them for I/O and glue logic for microcontrollers. You might want to expand the logic scope design to a full-fledged logic analyzer or digital storage scope. Larger FPGAs will even allow you to create your own custom CPU! **NV**

Parts List for DAC

R1, R2, R3, R4 — 22K 10% resistor
R5, R6, R7 — 11K 10% resistor
(two 22K resistors in parallel — see text)

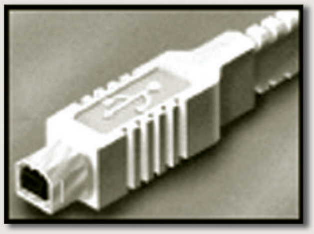
Figure 8. The mask comparator schematic.

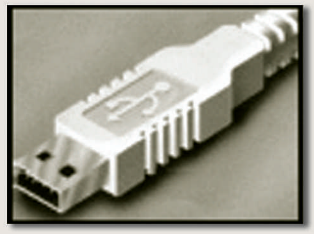


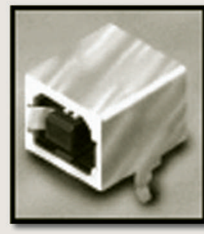
Circle #50 on the Reader Service Card.

Universal Serial Bus

by Hamid Namdar







Can you imagine connecting up to 127 different peripherals — like scanners, modems, storage devices, web cams, telephones, printers, and many others — to your computer at the same time, using them without any PC reconfigurations or rebooting? Don't imagine any longer because it is real and it's called USB (Universal Serial Bus).

USB is the answer to the development of all the new external peripherals for the PC platform. USB is low cost, fast, easy to use, bi-directional, and capable of real time data transfer of voice, audio, and video. Currently, USB 2.0 has a bandwidth of 480 Mbps, which is 40 times greater than the previous version — USB 1.1 — with a fully compatible bandwidth of 12 Mbps.

You might ask why only 127 different devices can be connected to a USB system. The reason is that a USB system uses addresses to identify different devices. The address field in a USB packet is seven bits long. The number of addresses you can create with this is two to the power of seven — 128 unique addresses. Address 0000000 is reserved for the default address and it is assigned to all devices upon power-up of the system. That leaves addresses 0000001 to 1111111 to use for the USB devices.

After the setup procedure of the system and the USB devices, each device on the system is assigned a unique address between 1 to 127 by the host for communicating with the computer. If you need to attach more than 127 USB devices to your computer, you will need a second host controller.

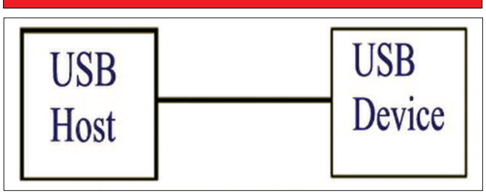
USB Architectural Overview

A USB uses a cable bus to exchange data between a computer and a wide range of peripherals simultaneously. These peripherals share the bandwidth of the USB through a host-scheduled, token-based protocol. By way of USB, you are allowed to plug, detach, configure, and use peripherals while the computer and other devices are in operation. The overall system of USB can be broken into three parts: *USB host, USB devices,* and *USB interface.*

USB Host

A USB system has only one host. Figure 1 shows a simple host-to-device connection. The host consists of the client software, USB system software, and USB host controller. Some of the responsibilities of the host are detecting the attachment and removal of USB devices, managing data control and flow, collecting status and activity statistics, controlling all access to the USB, granting access to the bus by a USB device, and providing power to some of the attached USB devices. The root hub (Figure 2) — which is integrated within the host system — provides one or more attachment points for the external USB devices.

Figure 1. A simple host/device connection.



USB Devices

USB devices must carry information for self-identification and generic configuration. USB devices are hubs or peripherals used to provide additional USB ports. Figure 3 shows a hub with seven

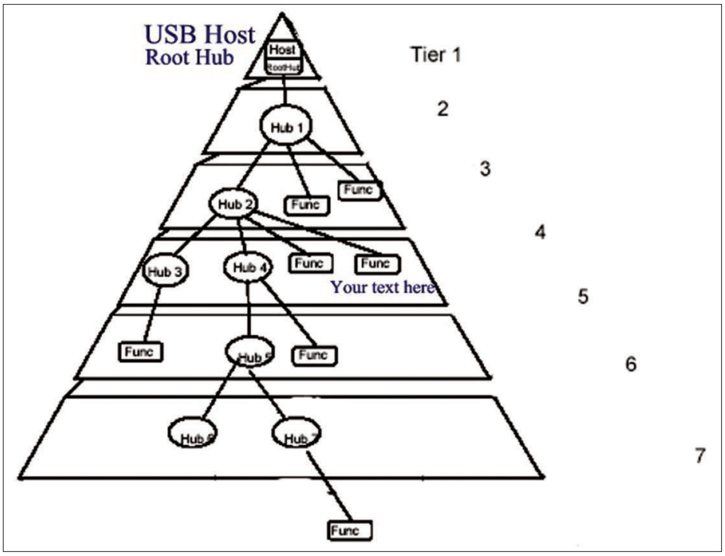


***Figure 2**.* USB topology.

attachment ports for devices. Peripherals like printers, keyboards, scanners, drives, cameras, and others are attached to the USB ports, each of which has a status bit that is used to report the attachment or removal of a device.

The host retrieves these bits from the hub and — if the status bit indicates an attachment of a USB device or another hub — the host will enable the port and give an address to the device. Then the device becomes ready for operation by the USB system. If the status bit indicates the removal of a USB device, the hub disables that port and tells the host that the device has been removed from the port. If a hub is removed from a port, the USB system software will remove all of the USB devices that were previously attached to the system through that hub.

Two kinds of USB peripherals can be attached to the ports: a bus-powered device that relies totally on the power from the USB cable and a self-powered device that supplies its own power for its operation. A hub also supplies power to the USB devices connected to its ports.

USB Interface

The interface is the manner by which the USB devices connect and communicate with the host. The physical topology of the USB host and devices is shown in Figure 2. As you can see, you are only allowed to attach five external hubs in series due to the hub's timing constraints and cable propagation delays.

A USB cable is used to connect the peripherals, hubs, and host together. This four-wire cable is used to transfer signal and power in a USB system (Figure 4). A twisted signal pair is used on each point-to-point segment for the signaling data rates of high speed (480 Mbs), full speed (12 Mbs), or low speed (1.5 Mbs). The diverse data rates allow a number of different bandwidth devices to be attached to the system.

The other two wires are used to deliver +5 V DC power to bus-powered devices. The USB cable can have variable lengths of up to several meters. Terminations are used at

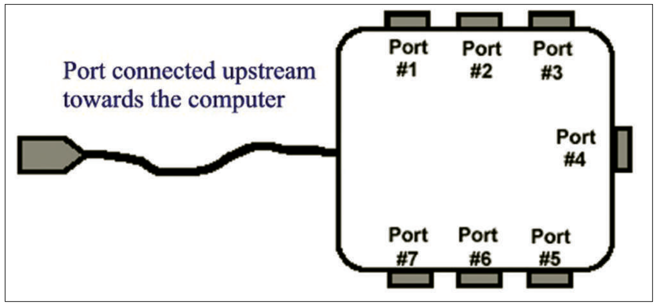


***Figure 3**.* A USB hub.

each end of the cable to permit the detection of attaching and detaching a device at each port; they also differentiate between the data rates of the signals.

As you see in Figure 5, the standard USB cable comes with "A" and "B" plugs at the ends. The "A" plug is always connected toward the host — or upstream. The "B" plug is connected toward the USB device — or downstream. Figure 5 also shows the receptacles for the "A" and "B" plugs.

USB Data Flow

We will now look at how data is moved across the USB system. To get a better understanding of this concept, we will look at the USB in a layered fashion. A simple view of

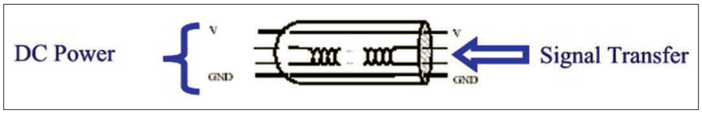
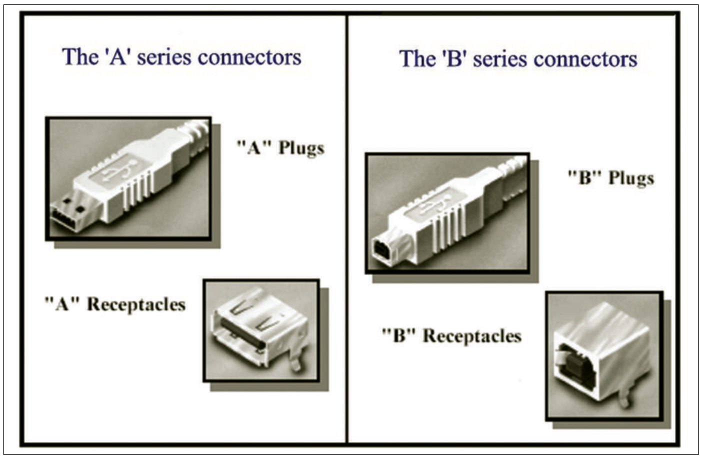


Figure 4. USB cable, four wires.

a USB host/device is shown in Figure 1. Figure 6 shows an expanded view of a USB host/device in layered form. The darkened arrows show the actual communication flow

Figure 5. USB cable connectors.



between the host and device. The lighter arrows show the logical communication flow within a layer. This basically shows that the function of the USB device is regulated by the client software via the actual communications flow. As seen in Figure 2, USB devices are physically connected to the host in a tiered, star topology; the host communicates with each logical device as if it were directly connected to the root port. The logical communication flow in the USB device layer is seen in Figure 6.

The rectangular boxes in Figure 6 show the four entities you need in order to implement a USB system. These entities are the client software, USB system software, USB host controller, and physical USB device.

The client software is executed on the host and corresponds to a USB device. The client software is usually provided along with the USB device or supplied with the operating system. Client software is only good for the particular device or function that it was written for and is independent of other devices that may be connected to the USB system.

The second entity you need for implementation is the USB system software; this is supplied with the operating system to support the USB logical device. The USB system software — which includes the USB driver, host software, and host controller driver — is independent of any particular USB devices or client software.

The USB host controller is also necessary; it is the

interconnection of the USB system to the computer. The controller could be implemented using hardware, software, or firmware. It initiates all data transfers through the system and communicates with the USB devices using a polled bus.

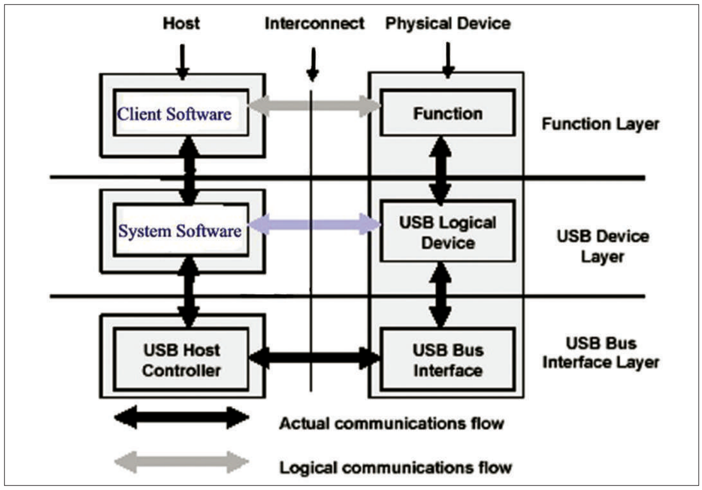
The controller, on a scheduled basis, sends out a token packet that has the information about the USB device address, type of data, and direction of transaction. All USB devices on the system will receive this packet and decode the address part of the packet. The device that is being addressed will start the transaction; data is transferred either from the device to the host or from the host to the device. To be certain that the data transfer was a success, the destination responds with a handshake packet. This is similar to networking between two computers.

The last thing you need to set up a USB system is the physical USB device — for example, a USB scanner. This USB physical device includes the function or device, USB logical device, and USB bus interface. USB physical devices furnish additional functionality to the host. The types of functionality provided to the host vary for each USB device, but all USB logical devices provide the same basic interface to the host. This is to let the host manage all USB devices in the same manner. USB provides an appealing solution for connecting different devices to a computer without any difficulties. With USB, you can expand your system's hardware without the limits on port availability.

USB allows devices from different vendors to interoperate in an open architecture system. The USB specifications allow vendors or developers enough room for product versatility without the burden of carrying obsolete interfaces.

USB's future looks good and we are seeing many new products with USB features. USB is here to stay — unless something better comes along. For more information, go to **www.usb.org** **NV**

Figure 6. USB host/device in layered form.



Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Applications

Expansion Made Easy

Interfacing the MCP23016

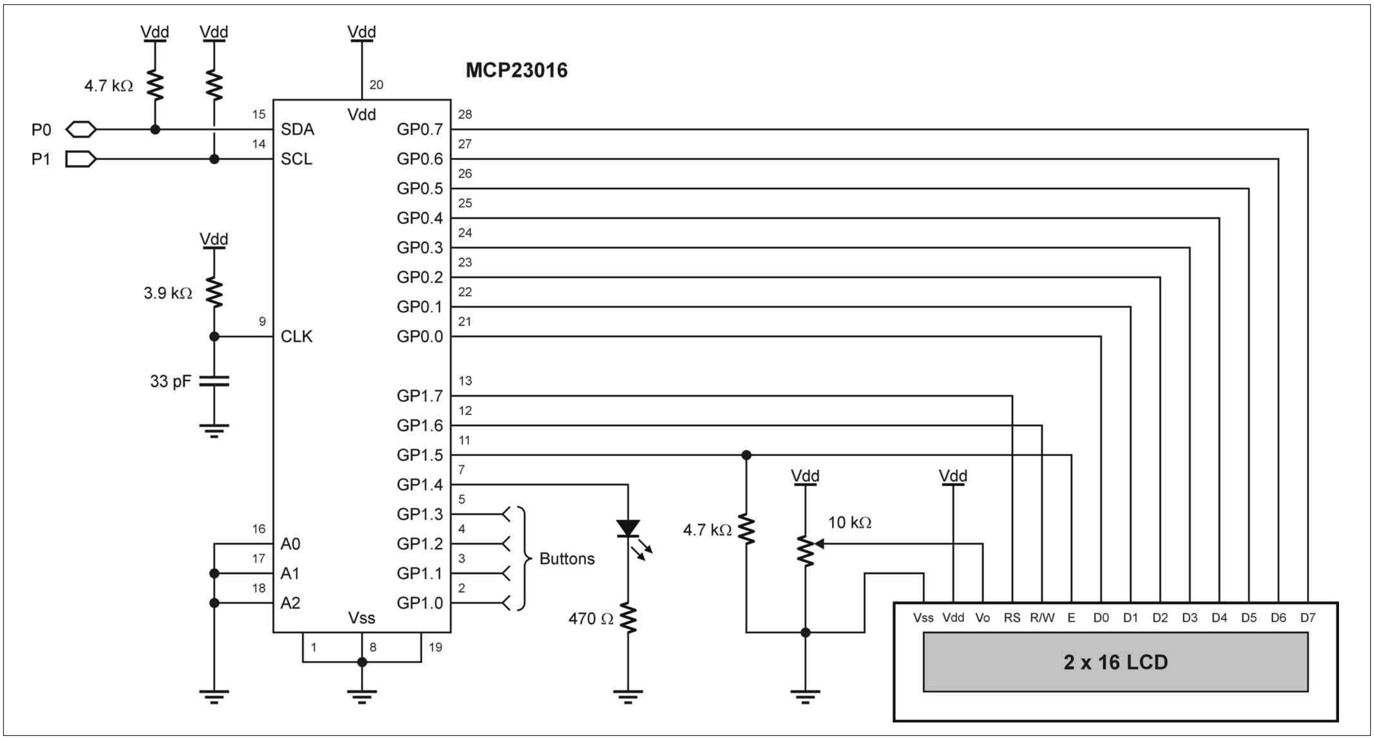
One of the great things about my job — aside from the fact that I get to work with BASIC Stamps all day long (and get paid for it!) — is the customer contact I am able to have. Almost all of my contacts are very friendly and find what I get to do here with *Nuts & Volts* useful — sometimes even a bit entertaining. Often, I get messages that are cries for help and I always enjoy helping, when I can. From time to time, a customer will alert me to a part that I hadn't previously worked with. That's always an adventure and sometimes those adventures result in finding a real gem.

Case in point: A couple of months ago, I got a note from a customer who was trying to connect his BS2p to a new part from Microchip called the MCP23016. As the part wasn't yet in production, he sent me one of his samples and it turned out that he had made a simple coding error. I was able to get the BS2p to control the MCP23016 without breaking a sweat.

Let me just say that this part rocks! Oh ... I'll bet by now that you're wondering what it is. The MCP23016 is a 16-bit (two ports) I/O expander; you can think of it as a much better version of the PCF8574. Why is it better? Well, for one thing, there's none of that *quasi-bidirectional* silliness of the PCF8574 (which is a *full-on* pain in the backside); its ports behave like those on a microcontroller — each having a DDR (data direction register) to specify what an output port does and (this is the best part) it can sink and source 25 mA per pin. Honestly, the MCP23016 makes the PCF8574 look like a schoolyard sissy.

Not long after I had worked with the MCP23016, another customer contacted me about creating an LCD interface with the PCF8574. I gave him some guidance,

Figure 1. MCP23016 LCD Terminal Schematic.



but I think you know where I stand with that device. Still, the idea is a good one: why not create a two-wire LCD interface with a $2.00 part? So that's what I did — using the MCP23016, of course. That's what I'm going to share with you here.

Easy I/O — Easy LCD Terminal

What I like most about the MCP23016 is that it's easy to deal with; we simply set the DDRs for the ports as needed, then write to them or read from them. Nothing could be simpler. As an added bonus, each port (eight bits) has a register that sets the polarity of the inputs. I like this because it lets us read active-low inputs to the MCP23016 as 1 (high) when they are active.

So let's get to it. What we're going to do this month is create an LCD terminal with the MCP23016, an LED, and four active-low buttons. The demo program will test all of the features of the terminal; later, we can strip out the demo stuff and use the subroutines in other applications.

Figure 1 shows the schematic of the MCP23016 connections to the LCD. Notice that we're using all eight bits of GP0 (port 0) to connect to the LCD data buss. This will simplify the code a bit versus the four-bit interface that we typically use. We need three bits from GP1 (port 1) for LCD control and the other bits are used to control the LED (an output) and the four buttons (inputs).

The MCP23016 has an internal clock circuit that is driven by an external resistor/capacitor combination. This clock determines how quickly the MCP23016 can respond to changes on its input pins to generate an interrupt output. We're not using that here, but we still need the RC circuit for the MPC23016 to run. The values shown are recommended by Microchip — just be aware that the clock speed affects the MCP23016's stand-by current consumption. Be sure to download the MCP23016 docs from Microchip for details on clock RC values and using the interrupt output and capture registers.

Okay, the connections are simple enough — let's jump into the code. As with any I/O port, we have to initialize the I/O direction bits as inputs or outputs.

```
Setup:
  PAUSE 500
  I2COUT SDA, Wr23016, IODIR0, [%00000000]
  I2COUT SDA, Wr23016, IODIR1, [%00001111]
  I2COUT SDA, Wr23016, IPOL1, [%00001111]
```

We start with a PAUSE so that the LCD and the MCP23016 can get through their internal reset operations. The next step is to set the pin directions. Let me point out a difference here between the MCP23016 and the BASIC Stamp. In the MCP23016, an output bit is specified with zero (0 looks like the letter O for output) and an input is specified with one (1 looks like I for input).

This code is written to be obvious and, after you get used to the device, you can take advantage of automatic address indexing on writes and reads by writing to both I/O DIR registers with one line of code:

```
I2COUT SDA, Wr23016, IODIR0, [%00000000, %00001111]
```

The final step in the setup process is to set the polarity of the input bits on GP1.0–GP1.3. When writing to a polarity register, a one bit inverts the input. Since we are using active-low button circuits, we want them inverted — hence the ones in bits zero through three.

Now that the ports on the MCP23016 are set up, it's time to initialize the LCD. For those of you who have worked with LCDs previously, this code will look quite familiar:

```
LCD_Init:
  lcdIO = %00110000
  GOSUB LCD_Command
  PAUSE 5
  GOSUB LCD_Command
  GOSUB LCD_Command
  lcdIO = %00111000
  GOSUB LCD_Command
  lcdIO = %00001100
  GOSUB LCD_Command
  lcdIO = %00000110
  GOSUB LCD_Command
```

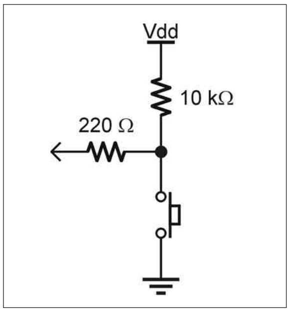


Figure 2. Standard Active-Low Button Circuit.

This section follows the standard Hitachi initialization sequence to put the display into eight-bit mode, using multiple lines and the 5 x 7 font. It turns the underline cursor off and causes the cursor address pointer to automatically increment after a write or a read. Of course, we're not writing directly to the LCD; we're doing it through the MCP23016 — so let's have a look at how that's done:

```
LCD_Command:
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  lcdRS = 0
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]

LCD_Write:
  I2COUT SDA, Wr23016, GP0, [lcdIO]
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  lcdE = 1
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  lcdE = 0
  lcdRS = 1
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  RETURN
```

You'll recall from our previous work with LCDs that a write can either be a command or a data byte for the display. The LCD distinguishes between a command and data by the state of the RS line; when we set the RS line low, the byte written is interpreted as a command and, when RS is high, the byte is interpreted as data to be written to the current cursor position.

What you can see, then, is that LCD_Command is just an entry point to the LCD_Write subroutine that takes care of setting the RS line low. In order to make the code work in other applications, we won't assume anything about the current state of RS; we'll read it back, modify it (make it 0), and then send it to the MCP23016. This must look like a lot of work, especially compared to the direct bit access we have on BASIC Stamp I/O pins. The truth of the matter is that PBASIC shelters us from this kind of detail; underneath the hood of the BASIC Stamp, the same kind of process is happening when we manipulate a single pin.

With RS setup properly, we can write the command that was passed in the variable *lcdIO*. The command is written to the LCD buss pins and then the LCD E pin is "blipped" high momentarily. The process is the same as with manipulating the RS pin — we read the current state, set it the way we want, and then send it back. Notice that, when we take the E pin back low, we return the RS line to a high (data mode). This lets us enter LCD_Write with RS in the proper state.

One of the reasons I like LCDs so much is the ability to have custom characters. Ten years ago, I created this little animation of a chomping mouth — and I've brought it back as part of the LCD interface test. The codes for custom characters are stored in **DATA** statements and then downloaded with a simple loop:

```
Download_Chars:
  lcdIO = LcdCGRam
  GOSUB LCD_Command
  FOR addr = CC0 TO (CC2 + 7)
    READ addr, lcdIO
    GOSUB LCD_Write
  NEXT
```

The process is straightforward: We set the cursor position to the Character Generator RAM and then write the data bytes that build those characters. Okay, we have what we need to get information to the LCD, so let's give it a try.

```
Main:
  lcdIO = LcdCls
  GOSUB LCD_Command
  addr = Msg1
  GOSUB Put_String
  PAUSE 2000
```

The top of our demo starts by clearing the LCD. This has a double purpose in that it also returns the LCD cursor to the Home position. Then, we write a string to the display with another subroutine. Like the custom character data, strings are stored in **DATA** statements so they can be re-used without consuming additional program space. Here's the code that writes a string to the LCD:

```
Put_String:
  DO
    READ addr, lcdIO
    addr = addr + 1
    IF (lcdIO = 0) THEN EXIT
    GOSUB LCD_Write
   LOOP
  RETURN
```

The string display works by reading characters from a **DATA** statement. The start of the string (and current character in the loop) is pointed to by the variable *addr*. After reading a character, the address gets updated, then is tested for zero. If it is zero, then we terminate the loop and return to the caller. If not, the character is sent to the LCD.

You may be wondering why we update the address pointer right after the **READ**, when the value could be zero. Well, by doing this, we can write two strings back-to-back without having to set the address of the second string. The only condition is that the strings must be stored in **DATA** statements in the order desired; otherwise, setting the starting address for subsequent strings is required.

With data in the LCD, let's see if we can read it back. This code is a little more involved, but not really difficult. What we have to do is set the GP0 pins as inputs and then put the LCD in write mode by making the RW line high. When we do that and set the E pin high, the LCD will

output the data at the cursor location to its buss pins. At that point, we read the byte from the LCD, set E and RW to their normal states, and make the GP0 pins outputs.

```
LCD_Read:
  I2COUT SDA, Wr23016, IODIR0, [%11111111]
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  lcdRW = 1
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  lcdE = 1
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  I2CIN SDA, Rd23016, GP0, [lcdIO]
  lcdE = 0
  lcdRW = 0
  I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  I2COUT SDA, Wr23016, IODIR0, [%00000000]
  RETURN
```

A test loop will read back the LCD characters and display them in the Debug window. Remember that the LCD cursor is set to auto-increment after any write or read, so we have to set it to the Home position (line 1, column 0) before starting to read.

```
Read_Demo:
  DEBUG CLS, "Reading from LCD: "
  PAUSE 500
  lcdIO = LcdHome
  GOSUB LCD_Command
  FOR column = 0 TO 15
    GOSUB LCD_Read
    DEBUG lcdIO
  NEXT
```

The final test of the LCD is the use of the custom characters that we downloaded during the setup process.

```
Animation:
  FOR column = 0 TO LastCol
    FOR idx = 0 TO 4
      lcdIO = LcdLine1 + column
      GOSUB LCD_Command
      LOOKUP idx, [2, 1, 0, 1, " "], lcdIO
      GOSUB LCD_Write
      PAUSE 50
    NEXT
  NEXT
```

The animation process requires two loops; the outer loop is used to set the cursor position and the inner loop sets the character to be displayed. Note that we have to reset the cursor position before each write because the LCD has been initialized to auto-increment the cursor. There's really no harm, since we need a bit of a delay between animation "cells" anyway — the time required for the write helps in that regard. A **LOOKUP** table is used to set the current animation character; in this case, we're using the custom character values zero, one, and two. The final character in the sequence is a space and what we end up with is a "mouth" — chomping its way across the LCD — and that removes our initial message.

Well, the LCD certainly seems to be working. Since our design is for a terminal with button inputs and an auxiliary LED output, let's go ahead and test them.

```
Button_Demo:
  lcdIO = LcdCls
  GOSUB LCD_Command
  addr = Msg2
  GOSUB Put_String

Show_Buttons:
  GOSUB Get_Buttons
  lcdIO = LcdLine2
  GOSUB LCD_Command
  FOR idx = 3 TO 0
    LOOKUP btns.LOWBIT(idx), ["-*"], lcdIO
    GOSUB LCD_Write
  NEXT
```

After clearing the LCD and writing "BUTTONS" on the first line, we'll put the program into a loop that reads and displays the button status. Reading the buttons is simply a matter of reading port GP1 from the MCP23016 and grabbing the lower four bits.

```
Get_Buttons:
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  btns = lcdCtrl
  RETURN
```

Remember that we don't have to invert the active-low button inputs, as the MCP23016 has been set up to do that for us (I love this feature). We could save a bit of variable space by aliasing *btns* to the NIB0 of *lcdIO*, but I decided not to so that things don't get mixed up, as *lcdIO* is used in so many other places.

Back to the button demo code — now that we have the current status, we can display each of them on the second line using **LOOKUP** again. Here, we'll use **LOOKUP** to select the character; as it stands, a dash means that the button is not pressed and an asterisk indicates that a button is pressed. I decided to do this because 0 and 1 are boring — but if that's what you want to use for one of your apps, you can change the **LOOKUP** line to this:

```
    lcdIO = "0" + btns.LOWBIT(idx)
```

Alright, we're almost home — the last thing we need to test is the LED. Just for fun, let's make it light when all of the buttons are pressed.

```
Update_LED:
  IF (btns = %1111) THEN
    GOSUB LED_On
  ELSE
    GOSUB LED_Off
  ENDIF
```


Finally, here are a couple of subroutines to update the LED, as required by the demo code:

```
LED_On:
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  IF (lcdLED = Is_Off) THEN
    lcdLED = Is_On
    I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  ENDIF
  RETURN

LED_Off:
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  IF (lcdLED = Is_On) THEN
    lcdLED = Is_Off
    I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  ENDIF
  RETURN

Set_LED:
  I2CIN SDA, Rd23016, GP1, [lcdCtrl]
  IF (lcdLED <> ledStatus) THEN
    lcdLED = ledStatus
    I2COUT SDA, Wr23016, GP1, [lcdCtrl]
  ENDIF
  RETURN
```

All of these routines are quite simple; we read the status of GP1, check the LED control bit, then update it — if required — and send the port data back. While our demo doesn't actually use the Set_LED routine, it's included because it will be useful when we want the terminal LED to follow a status bit from elsewhere in our application (that we've aliased as *ledStatus*).

Do note that none of these routines write the LED status bit to the MCP23016 unless a change is actually required.

Okay, we're done. How about that for a simple — yet abundantly useful — project? As I suggested some time back, I've become a very big fan of the I^2C buss and the MCP23016 is a great part to use with it.

A couple of final notes: Yes, you can control the MCP23016 with the BS2, BS2e, and BS2sx. You'll need to use manual I^2C code, since those BASIC Stamps don't have the I2CIN and I2COUT instructions. We did that back in the May 2002 issue (you can find that article online as a PDF on the Parallax website — **www.parallax.com**). Finally (I promise), the MCP23016 uses the same device address as the PCF8574A — so you can't mix them on the same SDA buss pin (but you can mix the MCP23016 with the PCF8574AP).

Have fun with the MCP23016; it's a great part — and, until next time, Happy Stamping. **NV**

Resources
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The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Statistics — Part I

Statistical analysis is an extremely powerful tool. It is important for an engineer to be familiar with techniques and methods of statistical analysis. Statistical procedures are often used to define reliability, but they are also very useful in signal processing.

Statistics Equates to Boring

I don't think I've met anyone (including myself) who liked any course in statistics. The professor lectures on and on about Type I and Type II errors and the "Null Hypothesis." It wasn't until years after my classwork that I understood the fundamental principles of statistics. At that point, statistical analysis became almost intuitive. It also became easy and I was able to apply it to many areas — including playing poker.

Statistics can be used to improve the signal-to-noise (S/N) ratio by an arbitrary amount. You can use statistics to make an eight-bit analog-to-digital (A/D) converter into one with 10 to 12 bits of resolution. Statistical process control allows manufacturers to make products with one in a million failure rates. You can use statistical modeling to see if your circuit will fail.

A Different Definition

My practical definition of statistics is: methods for extracting a signal from noise. When you take an average (the heights of people, for example), you are pulling a common value from a group. You can view an average as a signal that represents the group. More specifically, the individuals of the group are not identical, so there is some variation. This variation is typically defined as a "normal" distribution. The probability function of this distribution has a more familiar name; it's called a "Gaussian" distribution. Ever hear of Gaussian noise?

Let's look at a more concrete example. We say that a signal has a frequency of 1 MHz, but take a close look at a 1 MHz signal with a spectrum analyzer. As you narrow the bandwidth of the spectrum analyzer, the 1 MHz signal changes from a line into a bell-shaped curve. This is a Gaussian function — or a normal distribution! The "1 MHz" signal is really an average of many signals. The "cleaner" the signal, the narrower the distribution and vice versa. (This example is rather simplified.)

Now, suppose you have two signals — one is 1 MHz and the other is 1.00001 MHz. Using the spectrum analyzer, can you see if there are two different signals or only one? It's clear that you will need a very narrow bandwidth — about 10 Hz — to determine this because there is only 10 Hz between the two signals. Suppose you didn't have a 10 Hz bandwidth; you wouldn't see the second signal and you'd think only one signal was present. (This is also known as a "Type II" error.) In other words, you couldn't find the signal because of the noise (or the other signal). Perhaps you can now start to see why statistics is important.

Basic Rules

The spectrum analyzer performed all of the number-crunching for you. You simply turned it on and used it. Many statistical procedures require you to do the math yourself. In order to do this properly, there are rules that have to be followed.

The first is the concept of significant digits which is also called resolution or rounding error. You cannot increase the precision of measurements beyond what was measured (except for a special procedure, detailed later). My desk is 33 inches tall. That's two significant digits. It really means that the desk is between 32.5 and 33.5 inches high — or ±0.5 inches. Now I convert that into centimeters and get 83.82 centimeters — but that's four significant digits. I clearly didn't measure my desk to 0.01 centimeters or 0.004 inches. So I have to say that my desk is 84 centimeters high, maintaining two significant digits. Obviously, many calculations will exceed the precision of the measurement, but the final number must not do so. If I wanted to show that I really did measure my desk precisely, I would add the appropriate number of digits to the measurement — or 33.000 inches.

Number Classes

Not all numbers are created equal. Some are more useful than others; these are divided into four classes: Nominal, Ordinal, Interval, and Ratio (NOIR, which is French for black).

Nominal — or named — classes

have no actual value associated with the number. In gym class, you counted off by fours to get four groups. It didn't mean that group one was better than group two. It's easy to identify a nominal class. Just change the number to a letter (group one to group A). If there is no meaningful change, then the class is nominal. You cannot apply any statistical measure to nominal numbers.

The ordinal class puts things in order — high to low, large to small, slow to fast. There is a difference between these numbers, but it is not directly linked to the numerical value. Consider a race. There is a first place through a 10th place. The first place runner wasn't twice as fast as the second place runner; all you can say is that the first place runner was faster. Only specialized statistical procedures can be applied to ordinal groups.

The interval class uses incremental steps for its members. A good example of this is temperature measured in Fahrenheit or Celsius. Each degree is an equal step. The key limiting point of an interval class is that there is no true zero. You can't say that 1° C is infinitely hotter than freezing or that 100° F is 10 times hotter than 10° F. You can use some statistical procedures with this class, but you have to be careful.

The ratio class has incremental steps and a true zero. The Kelvin temperature scale has a true zero — it's called absolute zero. You can't get any colder than that. This class is the truly mathematical class. There are no mathematical limitations with these measurements. All statistical procedures can be applied.

The Normal Distribution

Except for special procedures, all of statistics is based on the "Normal Distribution." (As we saw earlier, this is also a Gaussian distribution.) What this means is that the average value of a group is the most likely value and that the farther a value deviates from the average, the less likely it becomes. It is critical to understand that, if this distribution does not hold, then common statistical procedures cannot be applied and the results are not valid. However, it is a rare case when the normal distribution is not valid.

Let's look at some resistors to illustrate this. If I take 200 loose packed, 1K Ω resistors and measure them, I expect that the average resistance will be very nearly 1,000 Ω. I also expect to find most of the values close to 1,000 Ω and fewer that deviate farther from 1,000 Ω. This is just common sense.

Notice, however, that I did not specify the tolerance of the resistors. Are they 1%, 5%, or 10%? The surprising fact is that it doesn't make any difference. The average — also called "mean" — for any tolerance is the same. When you stop to think about it, this is also common sense. While an individual 10% resistor may vary farther from 1,000 than a 1% resistor, the average of any large group of 1K resistors is, by definition, 1,000 Ω.

Of course there is a difference between the 1% and 10% distributions. If you were to graph the number of resistors and their resistance in 1 Ω increments, you would find that the 1% resistors were all within 10 Ω of 1,000 Ω. The 10% resistors had a different distribution. It would be more spread out and less peaked. Again, this is just common sense. Since the values are more spread out, there are fewer resistors at any particular value.

What may not be common sense is that these curves, while clearly different, have the same shape. The only thing that changed was the scale. A common analogy is looking at a sine wave on an oscilloscope. If you change the horizontal or vertical gain, the trace looks different, but, of course, it's still the same sine wave. The same is true for the resistor distributions. Both distributions are "normal," but one varies more than the other.

This brings up an important

point. Since all normal distributions have the same shape, you can define any particular distribution with a single number that identifies how much it varies. This term is called the "variance." The square root of the variance is more useful from a practical standpoint and is called the "standard deviation" or "sigma." Given a normal curve, 70% of the resistors will be within (±) one standard deviation of the average. Over 95% of the resistors will be within two standard deviations.

That doesn't mean that 5% of the resistors will be outside of their tolerance rating. The manufacturers make certain that virtually all of the resistors meet their rating. They used to do this by measuring them. Of course, that's too expensive to do today. Instead, they employ very stringent standards so that the manufacturing process guarantees that the resistors meet the specifications.

They do this by defining a very narrow distribution that is so tight that the actual specified resistor tolerance limit is often six standard deviations away from the average. A name for this is "six-sigma manufacturing" and it uses "statistical quality control." This means that there are only a few chances in a million that any resistor is outside the tolerance rating.

Non-normal Distributions

Non-normal distributions are unusual, but, when they occur, the results can be quite peculiar. Let's examine 1K resistors from way back when the 20% tolerance was the standard. If you bought a bag of 200 and measured them, the average would be 1,000 Ω. That's what you'd expect. While measuring them, however, you'd notice that there weren't any resistors between 900 Ω and 1,100 Ω. Instead of one distribution, you had two — one from 800 to 900 Ω and another from 1,100 to 1,200 Ω. Worse yet, these distributions weren't normal, either. They were lop-sided.

The reason for this is very simple. The resistor manufacturers measured every resistor and sorted them out according to their tolerance. Better tolerance resistors sold for more money. It was very cost effective for manufacturers to skim the lots for precision parts.

However, this meant that circuit analysis was compromised. A nominal 20%, 1,000 Ω resistor would never be 1,000 Ω. It would either be between 800 and 900 Ω or between 1,100 and 1,200 Ω. I think you can see the problems this could cause when resistor ratios needed to be made (as in a simple voltage divider).

Modern day components may also have non-normal distributions. This is especially true for tape and reel components.

Here's a real story (no pun intended): I had designed a very low-power transmitter that needed a small chip capacitor of 6 to 10 pF for peak tuning. I knew that the final value depended on manufacturing processes. I was surprised when the manufacturer said it couldn't be peaked. I visited the plant to determine the problem. It turned out that the "10 pF" capacitor had a tolerance of 20% and was actually 9 pF. They also tried using two "4 pF" capacitors in parallel, but these had a tolerance of ±0.75 pF and were actually 4.5 pF each. Two of these capacitors, in parallel, had a total of 9 pF, too. It's easy to see why they had a problem. Everything they tried was actually exactly the same. All the capacitors tested in the 10 pF reel were 9 pF and all the 4 pF were 4.5 pF. Why?

The manufacturing process for the capacitors doesn't vary much from piece to piece. Instead, there are drifts and changes over time. This means that capacitors that are manufactured at virtually the same time will have very similar values. Tape and reel packaging forces components made at the same time to be in close physical proximity until they are used. In this case, the normal distribution refers to millions of components over a long period of time. The statistical problem here was that the "sample size was too small."

Basic Tests

It's useful to be familiar with common statistical tests. We've seen how different distributions have different characteristics. You can compare distributions with "Analysis of Variance" tests. There are several, ranging from the fairly simple "F" test to complicated multi-variate forms. Truthfully, there is rarely a need for engineers to use this.

A more common test is one of averages used to determine if one group is significantly different from another group. For example, you have version A and version B of a receiver and you test 10 pieces of each and find that version A has an average sensitivity of -110 dB with values ranging from -106 to -120. Version B has an average sensitivity of -113 dB, with values ranging from -100 to -119. (Note that all statistics also apply to groups. Statistical procedures cannot be applied to a single piece or single measurement.)

Is version B really more sensitive than version A or is it just random variation? Since version B costs more, is the performance worth the extra price? You would use the "T" test for means (averages) in this example. It would tell you how different the two groups were in terms of a probability. That is, the answer would be something like 25%. This means that, 25% of the time, there is no measurable difference between versions A and B. You would then have to decide if the extra costs were worth investing into a product where 75% of the customers would see an improvement and 25% wouldn't.

It's interesting to note that most basic statistical calculations are as follows: sum the squares of the differences from the average and then take the square root. This is the same method used to find the Root-Mean-Square — or RMS value — of a signal.

Correlation compares two (or more) groups against some common factor. There is a clear correlation between drinking alcohol and car accidents and, in this case, there is a clear and direct link between them.

However, did you know that there is also a clear correlation between ice cream sales and boating accidents? Does this mean that we should restrict sales of ice cream to those over 18 or, perhaps, not allow open ice cream containers while boating? Obviously, there is only an indirect relationship here; the indirect relationship is one of warm weather activities. It's very important to realize that, while things may be highly correlated, they may have no direct relationship.

Correlation (and its related statistic — regression) is useful in engineering. In particular, a special type of correlation, called "auto-correlation," is used in signal processing. This procedure compares one part of a signal to another part of the same signal. This is a search for similar patterns. Telephone equipment uses this technique to eliminate echoes. It's a very powerful and useful tool.

One simple statistical test that I recommend for all engineers is the Chi Square test. (Chi is pronounced like "cry" without the "r.") This is a test for an expected result. If you roll a die, you expect six to come up once every six rolls, on the average, but, of course, six won't come up every sixth roll. There will always be some variation. The Chi Square test will tell you if the variation is normal or if the dice are loaded. It will also tell you if your system is failing more than you expected.

Good Stat, Bad Stat

Many areas of engineering rely on statistics. It is extremely important for any engineer to have some familiarity with them because, without that familiarity, engineers lose their ability to determine what is reasonable and what is not. Statistics is a tool. It can be used well and it can be used poorly. Do you know enough to be able to tell the difference?

In 1975, the Atomic Energy Commission published a study, headed by Dr. Norman Rasmussen, which placed the probability of a total nuclear meltdown at less than one chance per 10,000,000 per year. NASA had statistics that said the chance of a catastrophic Space Shuttle failure was one in 100,000. (Work it out. That's a launch every day for 275 years per failure.)

Whenever you see such probabilities associated with a complex mechanical system, be very skeptical;

usually these numbers are created by someone who has an agenda. They fail to consider outside factors (a falling piece of foam) and the fact that many events are not random (especially the behavior of people). Is it a machine failure if the design causes the operators to make poor decisions? Remember, according to Mark Twain, there are three types of lies: lies, damn lies, and statistics.

Signals and Noise

Earlier, I mentioned using statistics to improve an S/N ratio or increase the resolution of an A/D converter. Here's how you do that. If you take random noise and add different random noise to it, there is an increase in noise. However, some noise peaks are partially canceled out with noise troughs. The result is that, instead of doubling, the noise increases by the square root of two. If you add a signal to an identical signal, there is twice the signal — or an increase by a factor of two. So, if you can superimpose many signals, their sum increases faster than the noise and your S/N ratio increases. The amount of increase is equal to the square root of the number of summed measurements.

If you take four measurements, you can increase your S/N by a factor of two — or 6 dB. If you take 100 measurements, it increases by a factor of 10 — or 20 dB. There is no theoretical limit to this. This approach has been used very successfully in deep space communication, sensitive radar systems, geophysical measurements, medical imaging, and many other areas.

The key to this is that you must have your signals properly aligned so that they sum. Normally, this is accomplished with some form of triggering that you control, for example the pulse from your radar. If you can't do that, but you do have a powerful computer, you could sum lots of pieces of noise and then use autocorrelation to identify similar signals and then add those signals to further improve the S/N ratio. Gee, statistics is becoming more interesting.

You can use the same technique to improve the resolution of A/D converters. Suppose you want to measure a DC voltage to 0.1%, but you only have an eight-bit A/D on your microcomputer (µC). Eight bits gives you 1/256 — 0.4% resolution. Assuming that the DC voltage varies little when compared to the sampling speed of the A/D, you can take 16 eight bit measurements and convert them to a single 10-bit measurement or take 256 measurements and get 12 bits of resolution.

There is a special requirement for this. There must be enough noise in the system to cause variations in measurement. Here's why. Suppose your real value is 4.9 volts and you can measure only in full volts. You'll get either "4" or "5" volt readings. If there is some noise, the reading will vary between 4 and 5 volts. Since the real value is so close to 5 volts and, with a normal noise distribution (Gaussian noise), the 5 value will occur more times than the 4 reading.

Knowing the distribution of the noise (or measuring it) allows you to calculate the actual reading of 4.9 volts. Now you can see why a perfect system that only reads a single value — either 4 or 5 — cannot be improved upon with this method. In fact, some special A/D systems actually *add* noise for better performance!

Conclusion

Being familiar with statistics is an important part of being a complete engineer. It's a powerful tool that can allow you to do things that you thought were impossible. If you understand the fundamental aspects of statistics, it becomes more intuitive and much less intimidating. Next month, we'll continue with probabilities. **NV**

For Your Info ...

Book Recommendation. The most readable book on statistics I have found is *Statistical Analysis in Psychology and Education* by George A. Ferguson, published by McGraw-Hill. My copy is very old — a third edition from 1971. Newer editions are available (used) for a few dollars. The latest in-print edition also features co-author Yoshio Takane. This edition is quite expensive; I have yet to review it personally.

by Mike Keesling

Understanding, Designing, and Constructing Robots and Robotic Systems

Personal Robotics

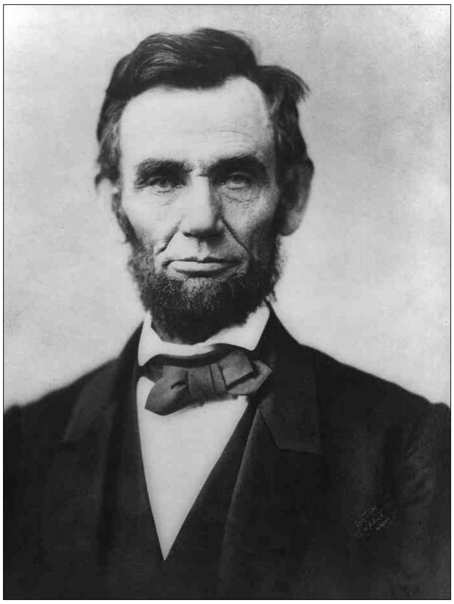
A Mouse's Eye View of the World

Let's face it, the real core of robotics is information processing. What is done with the information a robot gathers truly determines its behavior. At the simplest level, that information could be a series of commands and times to perform them. Even at that level, there is still sensing going on; in this case, we are sensing the ticks of a clock. While this is a great start, watching your robot roll off your desk or ram into a wall because it had no sense of its surroundings gets old really fast. Building a robot that responds to its environment is what people are on a perpetual quest for, but, to do that, we need perception.

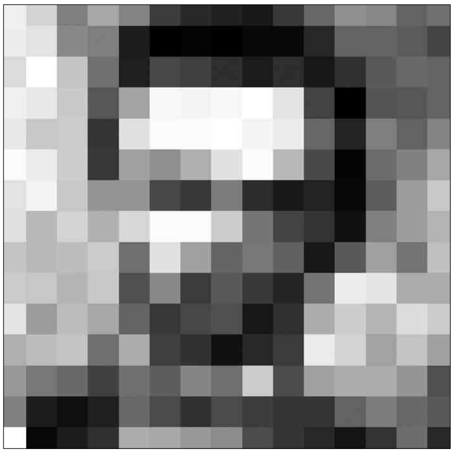
Typical sensors of the day include photo-resistive, photo-reflective, pyroelectric, optical triangulation, quadrature, and many others; however, if you make a list, you will find many optical sensors out there. Optical sensors are great because they are non-contact — they let you sense something without touching it. Of course, the king of optical sensors is the video camera. Wouldn't it be wonderful to attach a video camera to our robots and just see the world? The problem is, often times, we simply do not have the processing power to accommodate a video signal and, honestly, very often we do not need it.

Unknown to many, there are actually millions of miniature video cameras sitting on desktops across the nation. Inside every optical mouse is a miniature, 16 x 16 pixel array coupled to a digital signal processor. This little system is capable of capturing thousands of images a second and translating that information into motion information. Additional information can also be gained, such as feature sharpness and brightness — even 16 x 16 pixel images at six bits deep.

Original



Actual mouse-cam rendition



First off, before you go trouncing off to your local computer store or worse — destroying your mouse — a word of caution is in order; not all mice are created equal. First, make sure the Agilent logo is clearly visible on the bottom of the mouse, near the lens. There are now mice out there made by a giant software conglomerate that integrates the mouse's microcontroller on the same die as the mouse processor and sensor. While these could be adapted, the functionality we are after isn't available, as far as I know.

Another key buying point is that a true USB mouse will likely have the chip we want. A wireless may not. This gets troublesome because there are several mouse chips out there and you do not know what you are getting until you actually tear into a mouse and look at the part number on the back of the chip.

For comparison, examine Table 1 and the following information.

HDNS-2000

The venerable flagship of the line, typically found in the cheaper optical mice, is somewhat limited in its capabilities, but is still quite powerful.

ADNS-2030 and ADNS-2051

These are, currently, what you will

typically find in optical mice in the $20.00+ range. Wireless mice will often have the ADNS-2030.

ADNS-2610 and ADNS-2620

These are the newest in the product line. They are eight pin devices and have only serial capabilities. I have not yet seen them in a product.

Looking at the chart, the category "Image Dump" also includes the advanced register access. Via SPI, you can sense the roughness of the image (which could be used to determine focus), average brightness, maximum brightness, motion, and other configuration settings. With these, you have quite a bit of power in your hands.

To begin, you will want to download the relevant data sheets from Agilent (**www.agilent.com**). Go to the optical navigation selection and pick up all the datasheets that you can. If you really want to, you can go through the trouble of ordering samples, but, in all honesty, it is easier to buy a mouse or two. The onboard clock circuit and decoupling caps are all there and the odd pin spacing is accommodated. Also, mouse boards are generally only one-sided, which makes modifying them easy.

You will want to completely remove the existing microcontroller from the circuit. The easiest way is just to desolder and remove it, then make a jumper cable to your IsoPod™. Since designs differ from mouse to mouse, it is impossible for me to tell you exactly what to do. Because we are using two-wire SPI, we need to connect MISO and MOSI with a 2.2K resistor and connect MISO to the SDIO on the mouse chip.

I also connected SCLK to SCLK on the mouse chip. You should also connect PD on the mouse chip to PE3. As a matter of note, it is convenient to keep the LED as a status indicator if you decide to use external illumination. It turns bright when the mouse chip senses motion and that is a good thing.

	Voltage	Image Dump	Quadrature	SPI	PS/2	Max Speed (fps)
HDNS-2000	3.3, 5.0	No	Yes	No	Yes	1,500
ADNS-2030	3.3	Yes	Yes	Yes	No	2,300
ADNS-2051	5.0	Yes	Yes	Yes	No	2,300
ADNS-2610	5.0	Yes	No	Yes	No	1,500
ADNS-2620	5.0	Yes	No	Yes	No	2,300

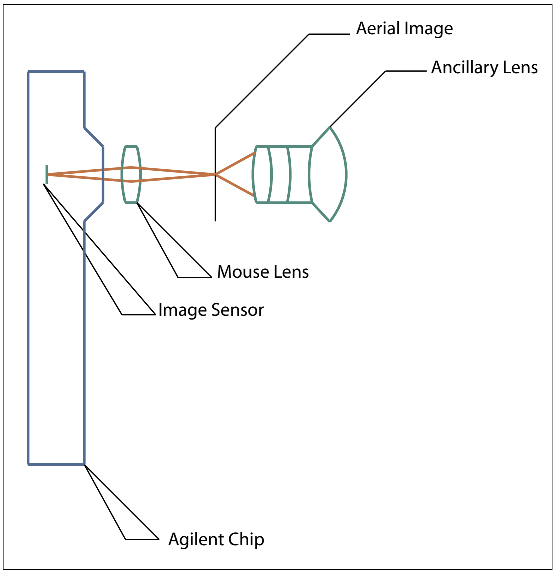
Table 1

Optics 101

One of the important things in optical systems is that, as you move your lens closer to your imager, the farther away you focus. Conversely, moving the lens farther away focuses on closer items. Well, in the case of the mouse, we are already focusing really close and, in order to focus further away, we would need to move the lens even closer. For our uses as a long-range sensor, we really want to be able to focus at a reasonable distance. Unfortunately, this is very difficult. The plastic housing would need to be machined with extreme precision and, even then, it is a real hassle.

This is where things get sticky. Rather than inundate you with the math, I will give you the course of action I came to and leave the math to the curious. There is enough technical stuff here to keep us busy and we can derive the results we need empirically.

To begin with, there are some



A dissected mouse-cam

obstacles in our path that we must overcome. First, the mouse's lens has a very narrow field of view; I calculate the lens to be 4.4 mm in focal length. Second, our mouse's lens is set for an extremely close-up focus. The mouse's image sensor is only 1 mm across. This means that it needs a wide lens to be of any use. These two limiting factors led me to search for a lens that was wider and would allow me to focus farther away. My solution was to find what is called a "board mount CCTV lens." I got lucky and found one that has a 1.9 mm focal length.

Remember our basic optical theory? It states that, as you move your lens closer to your imager, the further away you focus. This means that, to focus farther away, you need to move the lens even closer to the image sensor — a feat not easily achieved in such a small package. To further complicate things, even getting my 1.9 mm lens into the correct position proved to be difficult, as well.

The solution is to allow my 1.9 mm lens to form its image at the plane where the mouse's original lens is focused. By doing this, I am creating what is called an "aerial image" and using a relay lens. The new lens produces an aerial image that is captured by the mouse's original lens, which is now functioning as the relay lens. This has some advantages.

If I can carefully sand the slightest bit of material off the back of the mouse's lens and cause it to focus even 0.1 mm further away, I use more of the image area of the new lens to get a wider field of view. The disadvantage is that I lose light. For my purposes, I am more concerned with objects at one to two feet away, so I assume that I can provide additional illumination, as required.

This approach allows me to use the optical mouse without modifying the existing sensitive optics. If, however, you are compelled to image directly on the chip (and I would be very disappointed if you aren't), here are a few tips: If you remove the lens assembly, you will see a truncated cone with a hole. The image sensor is directly below it.

If you use a different lens, you may wish to open up this hole. To do this, you will need to remove the cover-plate, so that you can drill it out. Careful examination will reveal a slight indent at either end of the mouse sensor. These can be gently carved away and the cover can be carefully removed. This will allow you to work directly and easily with the sensor.

You can also build a pinhole lens. This will be mounted in place of the mouse's lens. To do this, take a piece of thin brass shim stock (0.005" works well), put it on an aluminum block, and press gently with a nail that is ground to a sharp point. Then take the shim stock and sand it flat with 400-grit sandpaper. The dimple you created will break and you be left with a nice pinhole. A pinhole lens will not be as sharp, but it will have better contrast.

Whatever course of action you choose to follow, there are a few tools that will be of great value:

- A 12 mm x .5 mm tap will allow you to build your own lens boards for mounting small video lenses.
- An eye loop or other magnifier.
- A flashlight with a diffused front lens and target. Create this by putting a piece of paper with a cross drawn on it into the lens assembly.
- A pair of "extra hands."
- A bright red LED.
- Laser pointer.
- Frosted Scotch® tape.

The key here is to break the chicken/egg syndrome early on. You need to find where your lens will form an image, but you don't want to build something just to find out that it does not work. If you are truly ambitious, you can build a series of different tubes, threaded on the inside, to accommodate your lens.

Table 2

04	05	06	06	08	07	08	08	10	09	08	07	07	06	07	05
05	06	06	07	08	09	10	09	12	11	11	09	10	08	07	06
06	07	07	09	09	11	11	13	15	16	15	13	11	10	09	09
06	07	08	10	12	14	15	19	20	22	20	18	14	13	10	09
06	07	09	11	15	17	21	23	29	30	28	22	21	15	13	10
07	09	12	14	18	22	30	34	44	45	44	32	28	20	17	13
06	08	11	14	19	27	37	54	63	63	63	49	33	25	19	13
07	09	10	15	20	32	47	63	63	63	63	63	42	28	17	11
08	09	12	16	21	31	53	63	63	63	63	63	44	24	16	11
07	08	10	14	21	29	51	63	63	63	63	63	43	23	17	10
07	09	10	15	19	30	40	63	63	63	63	58	34	22	13	11
06	08	12	16	19	25	31	42	52	58	47	38	22	18	13	10
06	08	09	13	15	17	22	25	29	31	30	24	16	15	11	08
05	07	09	09	11	12	16	17	21	21	19	18	14	12	09	07
04	04	06	07	06	09	09	11	12	13	12	11	10	08	06	05
05	05	05	06	07	07	07	09	09	11	09	08	09	07	06	32

Place Scotch tape on one end of the tube and thread your lens into the other, then aim it at your flashlight in a semi-darkened room.

At some point, looking at the tape with your eye loop, you will see your flashlight in focus, but upside down. In this way, you can see the distance at which a particular lens is forming an image. This will allow you to determine the dimensions of your lens board.

Back to the chicken/egg thing, it is somewhat difficult to get the lens centered on the sensor until you have working software and it is difficult to get the software going until you have working optics. Therefore, I highly recommend using the existing optics to flesh out the software.

Once you can take pictures of the surface of your desk, you can work on the optics. The surface roughness reading can be beneficial here, since a sufficiently rough surface will read as not rough if it is out of focus.

Again, the chicken/egg thing comes into play. A rough surface that is far enough away can still appear smooth if its features are too small to be recognized as features; think of a stucco wall at 20 feet away versus one that is two inches away. By working out the software on an optical system that is known to be good, you can test optical ideas once the software works.

A laser pointer with a Scotch tape diffuser can be helpful here to "break" the chicken/egg cycle, as well. It generates what amounts to infinite roughness. By aiming your laser at the sensor and looking at the motion registers or quadrature pins, you can see if you have broken anything. Aim the laser into the mouse and wiggle the pointer around. If you sense motion, then things are good.

Once you know where your new lens wants to focus, you can set up an LED and start taking pictures of it. To start, you will want to work in a darkened room. Set the mouse sensor and optic aiming upward. Then place the LED above it at some distance, centered on the mouse sensor.

It is easier if you have your ancillary lens focused at this distance. Next, take pictures and look at the data coming out of the lens, searching for a bright spot. Try to center this spot by moving the ancillary lens around.

Table 2 shows what the data coming out of my mouse looks like when it is centered on the lens. Notice the pattern of 63s. They are nearly centered in the data, indicating that the lens is nearly centered. Once you have it centered, you can affix your lens board with an adhesive, like hot glue. At this point, you can move the LED to a new distance, look at the data coming out, and focus it until you get the sharpest difference between low numbers and high numbers.

With these general optical tools at your disposal, you should have a reasonably easy experience getting the mouse to work.

The possibilities for this are really amazing. Imagine a line following robot that takes a picture of the line and uses an artificial neural network to determine how to steer in order to track the line. You could use a laser line generator; take pictures with and without the line generator on to detect terrain features.

You can even use it to do experiments in insect vision, called "optic flow," where you read the quadrature outputs directly to determine the motions of surrounding objects relative to you.

In the software I have provided on the *Nuts & Volts* website (**www.nutsvolts.com**), I have the IsoPod output generate HTML tables with colored backgrounds according to the pixel values of the image. You can save the output to a text file and as a UTF-8 file with the extension ".HTML." This will allow you to easily visualize the mouse's output.

If you have any interesting experiences with these versatile chips, please feel free to contact me at author@bio-bot.com **NV**

by L. Paul Verhage

Approaching the Final Frontier

Near Space

Experiments for Your Near Spacecraft

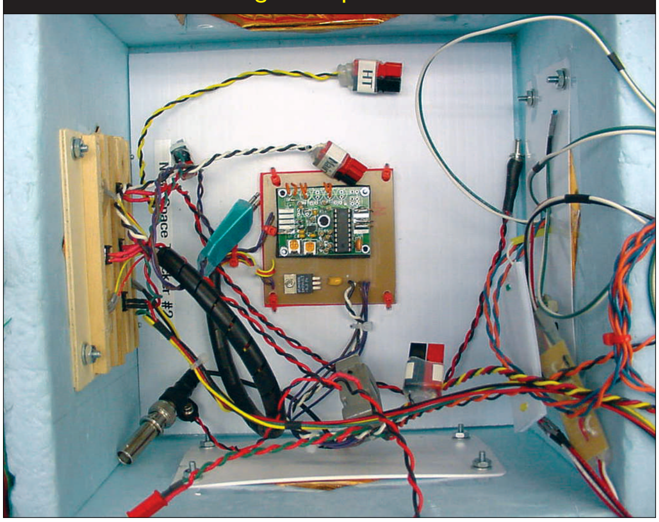
Now that you have a near space (NS) craft, what experiments can you perform with it? Since it has a simple tracker — not a flight computer — there are some limitations. There are many experiments that function on their own; however, before you can process your science results, you need to understand the format of the data transmitted by the Tiny Trak 3 in your NS craft.

Tiny Trak 3 Data Format

The Tiny Trak 3 is a PIC-based radio modem, although it might be better to call it an MO, since it does not demodulate radio transmissions. When programmed for amateur NS use, the Tiny Trak 3 uses data fields from two GPS sentences — the GPGGA and GPRMC. Elements from both sentences are combined into the Tiny Trak 3's posit. You can think of a posit as a condensed position and status report. As such, a Tiny Trak 3 posit contains enough data for you to perform some amateur science without carrying anything else inside of your NS craft.

The older Tiny Trak 2 works well as the NS avionics, but you should consider at least replacing its PIC microcontroller with the newer Tiny Trak 3 version.

The Tiny Trak 3, safely anchored in its reusable lunchbag near space module.



The Tiny Trak 3 posit contains a time stamp that is not found in the posits of the Tiny Trak 2. The time stamp is very useful when analyzing your data. There is a way to get around this that we'll cover at the end of this month's column.

A Sample Tiny Trak 3 Output

Example 1 shows the highest altitude posit received from one of my NS craft during a mission last year.

On this particular mission, my module transmitted posit reports every 60 seconds. The mission's science data was stored onboard for retrieval after recovery. This method of storing science data onboard has several benefits. For one, my important science data is not contaminated with packets from local hams and chase crews. Believe me, it can take several hours to clean up an APRS log. The second benefit is that there are no dropped packets to contend with. APRS is designed to be a robust communication method; however, packets are only transmitted once and there is no verification that they were received (this is important to consider, since the receiver is usually a moving target). As a result, posits are occasionally not received on the ground. This is not a problem for determining the landing zone of the NS craft, as there are still plenty of received posits, but, if you're sending science data over APRS, the missing data can be a real aggravation.

Format of the Tiny Trak 3

So what does the sample posit say? The posit from the Tiny Trak 3 uses the following format:

callsign, routing information, time, latitude, longitude, direction, speed, and altitude.

The FCC (Federal Communications Commission) issues you a callsign after you earn your amateur radio license. The callsign is unique to you and is used for identification.

```
KD4STH-11>APT310,WIDE3-3:/143130h4313.72N/11721.12W>272/029/A=111840
```

Example 1

The callsign remains fixed for the entire mission of the NS craft (if not for every one of its missions). The -11 after the callsign is unique to packet radio and is called an SSID. Packet stations use SSIDs so that a licensed amateur radio operator can own several packet stations that run simultaneously. The SSID is used to identify the station transmitting the packets. In the example above, the -11 SSID is used to identify the transmitting station as a balloon.

The next field indicates which version of APRS is being used by the TNC (Tiny Trak 3, in this case). This field stays constant for the Tiny Trak 3.

The routing information — in this example, "WIDE3-3" — indicates how many "bounces" a packet signal is allowed. Packet signals can be digi-peated. This occurs when a packet station that is set up to do digi-peating receives the posit report from your NS craft and retransmits it. The "-3" indicates that the posit report is allowed to be digi-peated a maximum of three times. The proper number of repeats appropriate for your module is determined by the standards used by packet radio operators in your area. Contact your local APRS user community before entering your WIDE setting. Both the callsign and routing information are programmed into the Tiny Trak 3 before launch.

The time stamp in the posit is derived from the GPS receiver and is given as time — UTC (think Greenwich Mean Time). The time stamp format is HHMMSS, with the hours given in 24-hour time. There are no commas between the hours, minutes, and seconds. The field ends with "h."

Latitude and longitude are given as degrees and minutes. Notice that there are no delimiters between the degrees and minutes. The minutes of latitude contain a decimal point. The field ends in the letter "N," indicating that the field is latitude north; the "W" in the latitude field indicates west. There is a slant separating the latitude and longitude fields.

The next two fields are pulled from the GPRMC sentence.

The first is the heading of the GPS receiver (the direction that the GPS is traveling). Since the GPS is attached to the NS craft and its balloon — which is prey to the ambient winds — this field is also the direction of the wind. The heading is measured by true north, not magnetic north.

The second GPRMC field is the speed at which the GPS receiver is traveling. This is also the wind speed. The unit of speed from a GPS receiver is given in knots. A slash is used to separate the heading and speed fields.

The last field is altitude, measured in feet. The Tiny Trak 3 converts the altitude units from the GPS receiver from meters into feet. The altitude field is indicated by the "A=" preceding the altitude.

This is all there is to the Tiny Trak posit report. If you'd like more information on the format of posit reports, consult the APRS Protocol Reference site (**http://web.usna.navy.mil/~bruninga/aprs.html**).

Processing Tiny Trak 3 Posits

Now that you know the format of the posits that you have received from the NS craft, let's discuss how to process the data after a mission; this is called post-processing. Did you think the mission was over once

This is a small excerpt of the cleaned up log.

```
12,49,29,42,57.90,117,00.77,000,000,004481
12,49,59,42,57.89,117,00.76,119,006,004832
12,50,30,42,57.89,117,00.77,126,004,005416
12,51,29,42,57.92,117,00.66,111,009,006656
12,51,59,42,57.96,117,00.54,078,010,007279
```

Example 2

KD4STH-11>APT310,WIDE3-3:/143130h4313.72N/11721.12W>272/029/A=111840
KD4STH-11>LIME,WIDE3-2:/143130h4313.72N/11721.12W>272/029/A=111840

Example 3

143130h4313.72N/11721.12W>272/029/A=111840

you got home? Either you or one of your crew members will have saved a TNC log of the flight. It is a copy of all the APRS traffic during the mission. This is a text file, so it's readable with a text editor, like Wordpad (it may be too large for Notepad).

Open the TNC log with the text editor of your choice. The first thing you'll notice is that there is a great deal of traffic from chase crews and local hams. In fact, most of the text you see has nothing to do with the posits from your NS craft. Make yourself a cup of tea because you're going to be editing the TNC log for some time.

The first step is to delete lines of text that did not originate from your Tiny Trak 3. Delete every sentence that does not begin with your callsign. Save your file frequently.

If a digi-peater was within range, you'll see some posits that were repeated before getting to your APRS station. In those cases, you'll see something that looks like the data in Example 2.

Notice that, except for the destination field, the second posit is identical to the first one. Realizing this, our next step is to delete all of the repeated posits. I prefer to do this manually to ensure accuracy. Before making deletions, look carefully at the posits. There may be times when you only see the repeated posit, not the original one. Be sure that you don't delete the repeated posit if your TNC log does not contain the original posit. Save your work again.

Next, get rid of the callsign and routing information. In Example 2, this means:

KD4STH-11>APT310,WIDE3-3:/

Here's where the Find/Replace feature comes in handy. In WordPad, select "Edit," then "Replace." In the "Find What" field, type the callsign and route text. Leave the "Replace With" field blank. Now click "Replace All."

Sit back and watch your PC make editing changes at warp factor six. You may notice that there were some damaged or repeated posits that didn't contain the information in the "Find What" field. You'll have to clean these up manually, unless you have lots of repeated posits. Save your work again.

Now you are left with sentences that look like that in Example 3.

Use the "Replace All" option to replace the following characters with a comma:

h
N/
W>
/A=
/

Be sure to do the last two in the order indicated and to save your work after every replacement.

Now you have posits that look like that in Example 4.

The last step is to add commas between the hours, minutes, seconds, and minutes of latitude and longitude. Again, I have found that it is more accurate to do this manually. Don't forget to save the changes frequently.

Your final result will be a text file that looks like Example 5.

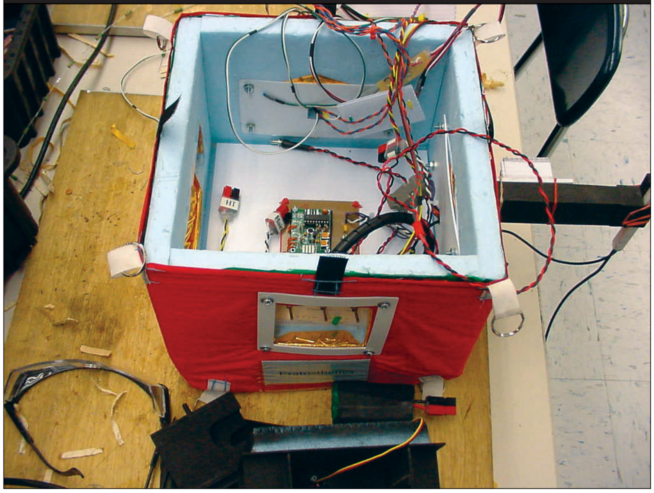
Congratulations — the hard work is over and the fun stuff begins.

You're now ready to import the text file into a spreadsheet. I'll explain how I do this in Excel. Even if you use another spreadsheet, you should find the procedure to be similar.

When you open the text file in Excel, it will ask how the text file is formatted. Tell the Text Import Wizard that the file is delimited and, in the second screen, specify that only commas delimit the file. On the third screen, click the Finish button. Look over the spreadsheet and verify that there were no errors in formatting the TNC log.

If you find an error, back out of the file without saving it, make the necessary changes to the modified text file, and then repeat the process of importing the file back into Excel. If you're happy with the results, save the file. Now let's produce some science.

Inside the near space module. The sturdy sides insulate and protect the data logger so that your information stays secure.



Amateur Science Experiments and Engineering

There are two levels of experiments and engineering that you can do with your current NS craft. This month, we'll examine the first, which uses only the raw posits from the Tiny Trak 3. Next month, we'll look into experiments that combine a stand-alone data logger with the posits.

Here are some of the simplest science and engineering results you can generate with your spreadsheet of posits:

- Altitude of the NS craft over time.
- Ascent rate as a function of altitude.
- Wind speed as a function of altitude.
- Wind direction as a function of altitude.
- Descent speed as a function of altitude.

To generate these charts, begin by creating a new column in the spreadsheet called "MET" (Mission Elapsed Time).

This is the time since the launch of the NS craft. If you didn't record the exact time, you can estimate it fairly accurately with the altitude fields of the spreadsheet. In the MET column, add the result of the hour's cell, divided by 60, to the minute's cell and the result of the second's cell, divided by 60. The equation looks something like this:

= (H/60) + M + (S/60)
in Excel:
= (+B3/60) + C3 + (D3/60)

Paste this equation into a couple of cells and determine the time of launch in minutes since midnight, UTC. Let's say that you determine launch to have occurred at 640 minutes after midnight, UTC. Modify the equation by subtracting the launch time, so that your equation now looks like this,

= (H/60) + M + (S/60) - 640
in Excel:
= (+B3/60) + C3 + (D3/60) - 640

Copy and paste the final formula into every cell in the MET column.

With the MET column completed, you can create the "Ascent Rate" column. In the second cell of this new column, subtract the current altitude (CA) from the previous altitude (PA). Divide this by the difference of current MET (CM) subtracted from the previous MET (PM). This equation divides the change in altitude by the change in time, yielding an ascent rate. The equation will look like this:

= (+CA - PA) / (CM – PM)
for Excel:
= (+H4 - H3) / (D4 - D3)

Copy and paste this equation into every cell of the Ascent Rate column.

Before creating your charts, delete any calculated cells that are in error because of missing data. You'll see impossibly high rates when the equation tries to use an altitude or time from empty cells.

If you're not familiar with speed

143130,4313.72,11721.12,272,029,111840 **Example 4**

14,31,30,43,13.72,117,21.12,272,029,111840 **Example 5**

measured in units of knots, then create a new column for mph data called "Speed." In this column, multiply the speed (S) measured in knots by 1.15. The equation will look like this:

= S * 1.15
for Excel:
= +J3 * 1.15

Copy and paste this equation into every cell of the column.

Create Your Charts

There are two charts I want to discuss in detail. On the "Altitude Over MET" chart, notice that the climb of the NS craft is very constant, except for a funny transition around 20,000 to 30,000 feet. For some reason, the balloon changes its ascent rate around this altitude. Before and after this transition, the climb remains uniform. Also notice the plunge after balloon burst. The parachute is opened constantly during descent, but, because of the low air density in NS, the first part of the descent is far more rapid. The increasing air density slows the module down as it approaches the ground.

In the "Wind Speed Over Altitude" chart, look for the jet stream. Around an altitude of 40,000 feet, the wind speed will peak. Depending on how close you got to the center of the jet stream, these winds can exceed 100 mph. Just wait until you chase a NS craft that is traveling at 120 mph! Fortunately, you'll notice that the jet stream is very narrow. It doesn't take the module very long to rise above the jet stream and slow down.

More advanced charts can be created using spherical trig to calculate NS craft range azimuth and elevation from the launch site as a function of MET or altitude. We'll look into this in a future column.

If you used a Tiny Trak 2 for your mission, you can still get useful data with a little more effort. Just remember the frequency for data transmission that was programmed into the Tiny Trak 2. After you create the MET field, increment each MET cell by the time between transmissions. To determine the location of missing posits, create a chart of altitude over MET.

Remember that the ascent into NS is smooth, so abrupt changes in altitude show where your spreadsheet is missing posits. Increment the MET cells involved with abrupt altitude changes until the final chart has a smooth altitude over time. Once this is done, you can create your charts as discussed above.

In next month's column, we'll compare a variety of data loggers, learn how to program them to collect the data required, and convert some of this data into easy-to-understand charts. **NV**

Tech Forum

QUESTIONS

Where can I get a circuit for a switching power supply used for a high/low intensity halogen lamp or even a replacement supply? The one I have is a wall wart type, which has an output of 12 and 8 volts AC to power the lamp. There isn't any other information on the case, aside from in and out voltages. Besides being cheap, I like the lamp.

#5041 **Tony Anzevino**
via Internet

I'd like a schematic on how to connect a transmitter/receiver made by **www.radiotronix.com** and sold by Mouser Electronics to use as a USB (v.1.1) wireless transmitter/receiver for my printer and/or scanner. I'd like to connect the transmitter (RCT-433-AS, through a male USB plug) to the PC's USB female plug and the receiver (RCR-433-RP) to the printer's USB male jack; the same would apply — only in reverse — for the scanner. The transmitter/receiver uses SMD components and would not take up too much space if fitted into a very small box.

#5042 **Dan**
via Internet

I will be moving to Europe and would like to take some of my hand-held power tools with me (e.g., a router). These tools are powered with universal motors and I wonder if I could build a triac-based controller to run these tools from the European 220 V grid or whether I would have to use a transformer. I can think of two potential problems: first, the brushes might arc excessively at 220 V and, second, there would be a greater risk of the motor burning if the tool stalled (this could, perhaps, be solved by a dedicated fuse). I would appreciate any comments and advice.

#5043 **F.X. Penney**
via Internet

I am tired of people breaking into my place. Is it possible to set up a remote video monitoring system — using my home PC with cable ISP as my base — to monitor my cabin (80 miles away) through telephone service and a PC, with two cameras inside the cabin?

#5044 **Albin Bauer**
via Internet

I need a schematic for a transformerless power supply with 120 VAC input and 12 volts at 40 amps or 24 volts at 20 amps output. Can anyone help with either a schematic or website where I can find one?

#5045 **Norm Doty**
via Internet

I have owned a Fluke 8020A multimeter for about 10 years. It is no longer usable, as the display has turned black. I have contacted Fluke and they do not have a replacement display for this meter — their solution is to buy a new one. I really can't afford to buy new digital multimeters every 10 years. Does anyone have a solution to my problem?

#5046 **James Blair**
Cypress, CA

I'm looking to buy a very powerful ultrasonic transmitter to send waves down the casing of an oil well (2,000 to 3,000 feet deep) and create motion in the fluid. Does anyone have any sources for such a device?

#5047 **Freeman Pickett**
Gonzales, TX

Is it possible to purchase equipment for discovering the identity of a phone caller that the *69 dial

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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ANSWER INFO

• Include the question number that appears directly below the question you are responding to.
• Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
• Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
• Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

To be considered

All questions should relate to one or more of the following:
1) Circuit Design
2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

Information/Restrictions

• No questions will be accepted that offer equipment for sale or equipment wanted to buy.
• Selected questions will be printed one time on a space available basis.
• Questions may be subject to editing.

Helpful Hints

• Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
• Write legibly (or type). If we can't read it, we'll throw it away.
• Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

back service reports as an unreachable private line?

#5048 **Ed Research**
Indiana, PA

I have just finished building a small CNC router table. It works well for making relatively shallow cuts, like in PCBs. I would like to start working with plastics, like Lexan and PVC. These are more difficult to cut with a small CNC router, since they are normally 3 to 6 mm thick. I know of ARC welders that can be used to cut through sheet metal, but I am looking for "simple" lasers that can be used to cut through these plastics and not metal. Is there a solution out there?

#5049 **Ronald Wijngaarde**
The Netherlands

I have an old keyboard (from a Wyse 2108 computer, vintage 1988 or so). It has a fantastic touch that I have been unable to find in modern keyboards. I've tried all 24 possible combinations of the four signals in an adapter cable, but none of them works. I'm guessing that there is some other incompatibility preventing this old keyboard from working on a more modern computer.

Can anyone point me toward the parts and instructions I would need to build a new keyboard from this old one's keys and a modern PS/2 bit of electronics or suggest another way to get it to talk to a PS/2 keyboard port?

#50410 **Dick Steffens**
via Internet

Can anyone suggest a source for negative-acting, photo-sensitized boards, such as those Kepro used to supply?

#50411 **Don Wruck**
via Internet

ANSWERS

[1048 — January 2004]

I have a Super 8 motion picture camera that runs on a 7.2 volt battery, but doesn't run in sync with the sound, which I've recorded on a digital real time recorder.

I'm looking for kits or plans to build my own crystal sync for a 7.2 volt motor. I tried searching the Internet, but there is no information available! Thank you!

#1 It may be impractical to add crystal sync to your Super 8 camera unless you want to heavily modify the camera — a job best left for professionals. You'd need a service manual first and you'd be attempting to control the motor speed while sampling its speed with some sort of tachometer device. That signal would be fed to a phase locked loop and compared to a crystal-based reference. It's a very ambitious project and not at all for the casual tinkerer. However, there is another alternative that might work, depending on what type of film you are trying to produce and requires no equipment modification.

If your final film is to be edited and shown on a Super 8 sound projector with magnetic stripes on the film, here is a suggestion. Most cameras and projectors run at a fairly stable — but perhaps inaccurate — speed. Try loading your location sound into a computer with an audio editing program.

The program will allow you to make adjustments to the speed of the audio without changing pitch. With a bit of experimentation, you should be able to get your sound to sync with your film for at least a minute or so. You can then dub it — perhaps in short sections — to your magnetically striped film as it runs through your sound projector.

Sure, there are limits to this, but, if you are committed to shooting and showing Super 8 film, it may be your cheapest fix. Try downloading the open source program Audacity — it's free and very cool (**audacity.sourceforge.net**) and available for PCs and Macs. It has all the features you will need to not only correct your sync, but to actually build a soundtrack.

Jim Addie
La Grange Park, IL

#2 To mangle a metaphor, you're trying to pull the horse with the cart. The Society of Motion Picture and Television Engineers (SMPTE) has written the prevailing standard for dealing with synchronization in this field. SMPTE time code allows for various frame rates, specifically 30, 29.97, 25, and 24 frames per second (fps), with some rates requiring "drop frames" every so often for accurate synch. Among other things, the different rates in the SMPTE standard allow black & white and color NTSC & PAL video and motion picture frame rates to be synchronized with audio.

The "gotcha" is that this is not implemented in the industry by altering the camera or frame rate speeds; what is changed is the sampling rate of the audio. Where normally one would use strict sampling rates of 44.1 (CD), 48 (digital tape), or 96 kHz (various digital recorders) for sound, the SMPTE code causes a controlling unit to slightly alter these audio sampling rates in order to keep the media in synch. MIDI time code (MTC) can also be used in some cases, for example, synching a digital recorder with an analog tape machine.

I don't know much about Super 8, but I would imagine that, if you don't want to move to video tape, the best thing you can do is transfer your film images to digital form and then use a standard computer application, like ProTools, to synch up your audio and video.

Technologies that are no longer on the cutting edge lose their value quickly, even though they are still quite serviceable and can be picked up very inexpensively on eBay. I suspect that any homebrew approach is going to cost you more than a little research and some well placed bids. For more on SMPTE time code, try: **www2.sfu.ca/sca/Manuals/ZAAPf/t/time_code.html**

Mark Emery Bolles
Alamo, CA

[10415 — January 2004]

I have a Compaq Presario 1277 laptop with a Li-Ion battery bearing the notation "14.8 V, 3.2 AHr." I'd like to know what this actually means and, if possible, how to calculate the battery's actual output, the amount of time it will supply needed power, etc.

Also, is it possible to replace this battery with a homemade solution, based on something I read several issues back about super capacitors (1 farad and greater)?

If the battery is rated at 14.8 V, 3.2 AHr, that means that, in theory, it can supply 4.8 volts at 3.2 amps for 1 hour or 14.8 x 3.2 = 47.36 watts for 1 hour. In practice, this value is dependent on the discharge rate — you usually get much more life at low discharge rates. As an example, if you discharge the battery at 0.1 amps, in theory, you should get 14.8 volts for

3.2/.1 = 32 hours, but, in practice, you might get 60 hours out of it. Also, if you discharge at a high rate (like 10 amps), you might get much less usable power (watts) out of the battery. In any event, this battery is capable of supplying far more power than any "Supercap" solution you are likely to be able to afford. It's also much more compact.

The energy stored in a capacitor is equal to 1/2 CV ^ 2. A 1 farad capacitor at 5 V stores 1/2 x 1 x 5 ^ 2 joules = 12.5 joules, which is 12.5 watts for one second or .00347 watt hours. Since your battery supplies 47.36 watt hours, the capacitor can supply .00347/47.36 = .0000733 of the power of the battery pack.

Robert Zusman
Scottsdale, AZ

[2042 — February 2004]

We are searching for a solution to the problem of the ultrabass sound from stereos in cars that drive down the busy street we live on. The loud bass noises and vibrations penetrate our house, setting off resonances that rattle our walls and windows. The rumbling from other vehicles — buses, trucks, and trains — is also an aggravation.

Is there a technology available that could cancel out these noises? Or, perhaps, is there a metal screen that could be plastered into the walls and have a charge applied to it that would cancel out the low frequency sound waves — similar to the screen embedded in the glass of the microwave oven door?

We would appreciate help with this problem, which is becoming more persistent.

#1 There is technology available that can cancel "predictable" or "coherent" types of noise, such as the roar of an airplane engine or continuous traffic noise. Such technology has been applied in noise cancelling headsets worn by pilots and in the headrests of some automobiles. Microphones in each earpiece pick up the sound waves at about the same time as they hit your eardrum. The noise cancelling circuitry "inverts the signal" produced by the microphones and produces a sound wave at the speakers that is 180 degress out of phase from the original. When the two waves hit your eardrum, they cancel and the sound is heard at a reduced level or not at

[1045 — January 2004]

I'd like to build a simple interval timer to run a 12 volt CPU cooling fan. It should turn the fan on for five minutes and then off for about three. If it is adjustable, that would be even better.

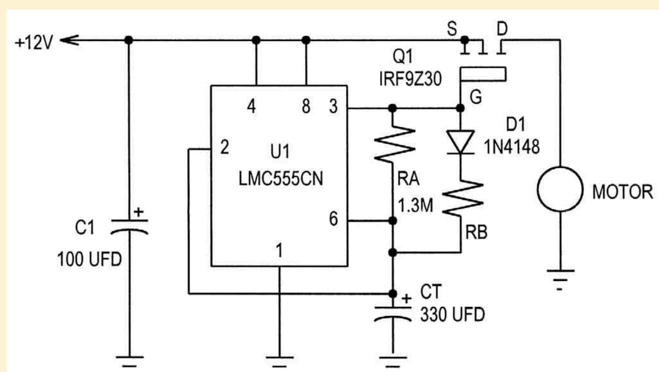
A very simple circuit using a CMOS 555 timer and a P-channel HEXFET can be used to operate a motor in an off/on sequence, as shown in this schematic diagram.

The 555 chip is operated in a slightly modified 50% duty cycle circuit where the on time of the motor is determined by the values of RA and CT. This time can be calculated from the expression T = 0.7 (RA) (CT) where RA is in megohms and CT is in microfarads. The motor is turned on when the output of the chip is low. RA can be made variable to adjust the on time of the motor.

Values of 1.3 MΩ and 330 µF will result in an on time of 300 seconds. A low-leakage electrolytic is recommended.

Without D1 and RB in the circuit, the off time of the motor would be the same as the on time. When D1 and RB are added as shown, CT is charged up faster during the time when pin 3 of the chip is high, resulting in a shorter off time for the motor. RB may be made variable to control the off time of the motor. A good starting value for RB would be about 1 MΩ.

Anthony Caristi
Waldwick, NJ



all. Digital signal processing is employed to filter and shape the signals for a greater effect. You can purchase a pair of noise cancelling headphones for under $300.00. The same technology has been developed on a larger scale using large loudspeakers and high-powered amplifiers to cancel unwanted noise in a room environment.

The technique works well for predictable types of noise. Blocking out the unpredictable noises found around the home — like those loud bass sounds you described — requires more sophisticated DSP software, which is currently not available for consumer use.

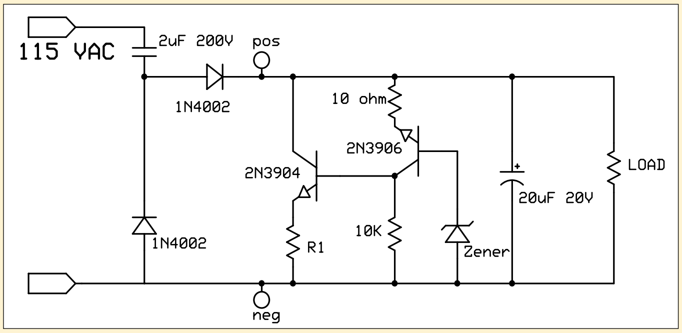
John Montalbano
Middeltown, NJ

#2 A physical barrier — such as insulation or a wall — is still the best way to block street noise. Large scale devices to cancel noise are used in some industrial settings, but only noise canceling headphones (such as Sony MDR-NC20) are available to consumers. The theory of operation is relatively simple, but the implementation is difficult. Since sound is a pressure wave, it can be canceled out by an "opposite" wave. When the pressure of the noise wave is higher than the background pressure, the canceling wave must have a lower pressure and vice versa.

[2041 — February 2004]

Does anyone have a schematic for a well regulated and efficient 120 VAC, transformerless power supply (no step down transformer of any kind — just diodes, resistors, caps, and voltage regulators) with an output of 9 or 12 VDC at 40 mA?

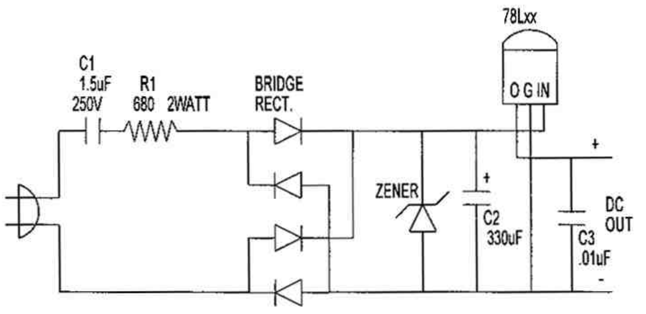
#1 An efficient power supply schematic is shown, though it is dangerous, because you have a good chance of getting the hot and return sides of the line reversed. This power supply is a current source, so a parallel voltage regulator is necessary. The 2 µF series capacitor should get you close to, if not quite up to 40 mA. Pick a Zener voltage that will equal your desired voltage. Subtract 1 volt, then multiply by 20 to get R1's resistance. For 9 V, R1 would be 160 Ω; for 12 V, it would be 220 Ω. In these examples, the power through the resistor is on the order of 0.5 W, so use a full 1 W part.



Alonzo E. Fuller
Grants Pass, OR

#2 The circuit below will supply a maximum of 40 mA. Keep in mind that this circuit is connected to the 120 volt power and is potentially lethal. The supply and the load must be enclosed in such a way that the user cannot be electrocuted.

Russell Kincaid
Milford, NH



PARTS LIST (MOUSER PART NUMBERS)

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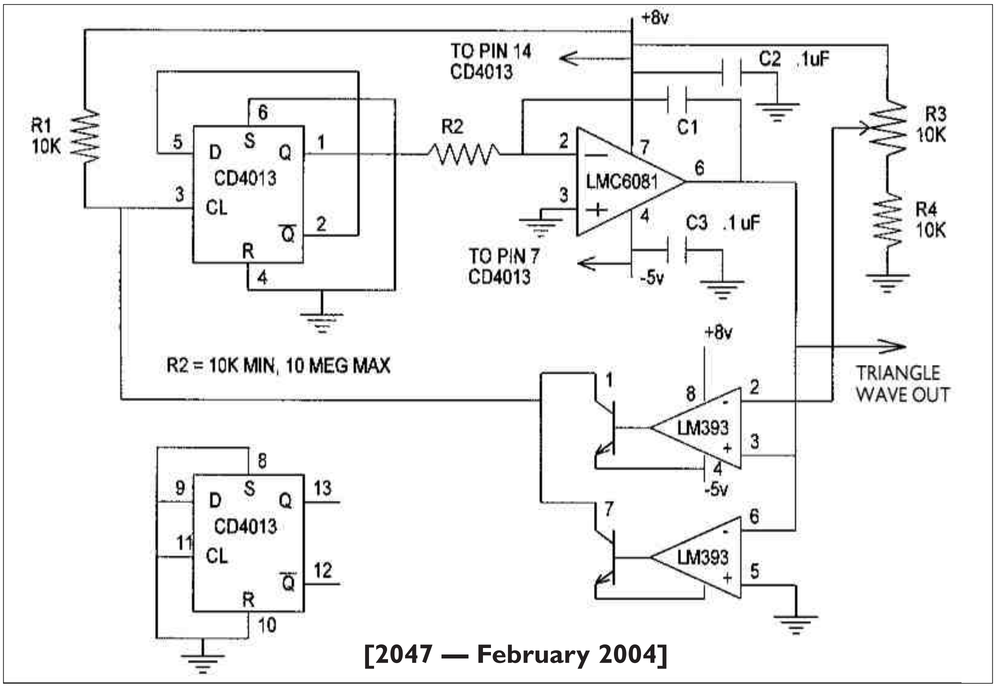
C2	75-516D337M025MN6A	25V, 20% TOL
C3	80-C410C103K5R	X7R, 50V, 10% TOL
R1	588-OY-680	2 WATT, 10% TOL
BRIDGE RECT.	625-DF04M	1 AMP, 400V 4 PIN DIP
ZENER	78-1N4744A	15V, 1 WATT
78L12	511-L78L12ABZ	TO-92, 12V, 100mA
78L09	511-L78L09ACZ	TO-92, 9V, 100mA

A noise canceling device consists of a microphone to detect the noise wave followed by circuitry and a speaker to produce the canceling wave. Cancellation is most effective for low frequency noises that don't change very suddenly.

Alan J. DeWeerd
University of Redlands
Redlands, CA

[2047 — February 2004]

I need to generate a 0 to 5 volt triangle wave. I tried to obtain this from a 555 timer chip, but it only produced a waveform that varied from 1/3 to 2/3 Vcc. Can anyone help me out with a circuit?



[2047 — February 2004]

The schematic shown will produce a linear triangle wave. The frequency is determined by R2 and C1 and the amplitude setting, R3. If R3 is set higher than 6.5 volts, the oscillator will hang. The supply voltages can be varied as long as the total doesn't exceed 15 volts and the positive is at least 1.5 volts higher than the triangle wave.

Russell Kincaid
Milford, NH

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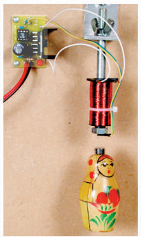

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*16 shot reference wave-form & set-up memory
*Built in autoranging True RMS Digital Multimeter
*Includes RS-232 I.F. software, RS232 cable & Rubber Boot

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> *Test Equipment* > *Hand Held Oscilloscope*

Circuit Specialists 20MHz Dual Trace Scope

Item# CSI6502

*20Mhz Bandwidth
*Alt-Mag sweep
*1mV/Div vertical sensitivity
*Alternate trigger
*X5 sweep magnification
*Large 6"CRT/autofocus
*Comes w/2 (x1 & x10) probes)

$269.00 !

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Non-Contact Infrared Thermometer

*Non-contact Infrared w/laser pointer measures -*50°C to 500°C/-58°F to 932°F
*Measure temperature of hot or moving objects from a safe distance
*Narrow 8:1 field of view
*Fast Sampling Time
*Switchable C° to F° and Auto Power Off
*Large 3-1/2 Digit (1999 count) backlit LCD with Data Hold

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Our Most Sophisticated DMM Ever!

Large 4 Dig backlit 8000 count dual display & Analog Bargraph. RS232 I.R.interface /software /cable 4 display modes, True RMS value & Freq. of Min/Max values:Temperaturein F/C; relative quantity & error % of relative value at the same time.

Item# CSI 8203..~~$189.00~~

Sale! **$129.00**

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RF Field Strength Analyzer $1499.

(Limited Offer)

The **3201** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2060MHz.The 3201 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RF transmissions

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XYTRONIC

A $35.00 Value !

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Item# 988-D

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*Tip temperature accuracy to within ± 3 °C (6°F)
*Zero Voltage switching and fully grounded design
*Adjustable temperature w/o changing tips
*Controlled by a finger actuated, thyristor switching circuit
*Detachable solder and desolder wands for ease of use and repair
*A self-contained vacuum pump engineered to provide continuous, maintenance free operation

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PROGRAMMABLE DC POWER SUPPLY

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*Stores up to 10 settings for fast & accurate recall
*Backlit LCD display
*High Resolution (1mV)
*PC compatible (with optional RS-232 adaptor module)
*Easy programming w numeric keypad or fast rotary code switch
*Power shut down memory function

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Normal brightness LEDs now available in RED, GREEN or YELLOW in 3mm or 5mm sizes.Your choice. *Each* bag contains 100 of the *same* LEDs.

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Super Bright LEDs Deal

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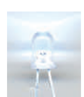
53BW3SCC08..5mm White SB LED	1+ $1.69 /10+ $1.49 /100+ $1.18
5Y3STC-2....5mm Yellow SB LED	1+ $0.25 /10+ $0.20 /100+ $0.15



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Synthesized Speech!

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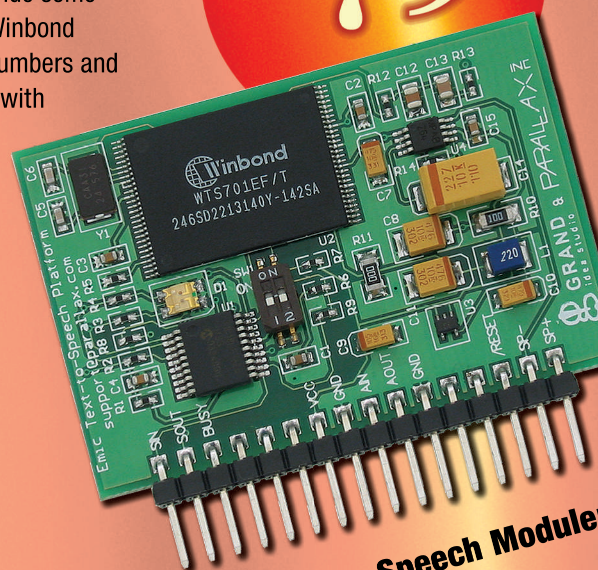
Parallax is the exclusive supplier of the Grand Idea Studio Emic Text-to-Speech Module. This module will let your robot speak, provide a real human-console interface to your control system, or simply provide some entertainment to your microcontroller projects. Based on the Winbond WTS701, this device intelligently handles values, sentences, numbers and common abbreviations with an extremely natural female voice with simple serial string sentences. OEM version also available.



Emic Text-to-Speech Module; #30006; $79.00

Features:

- True text-to-speech synthesis
- Capable of embedded phonetic control for foreign and difficult-to-pronounce words
- Easy-interface SIP format 2.0” long x 1.375” wide with 0.100” pin spacing
- Single +5V supply with TTL serial interface (2-wire, 2400 baud)
- On-board 300mW speaker driver
- Easy-to-use ASCII or hexadecimal command sequences
- Bicolor LED for visual feedback of activity
- Audio input pin for pass-through and amplification of BASIC Stamp-generated sounds
- Compatible with BASIC Stamp, Microchip PICs, any TTL-level processor and your PC’s serial port.

BASIC Stamp® code example:

```
SEROUT Emic, Baud, [Say, “BASIC Stamps are made in the U S A.”, EOM]
```

Order online at www.parallax.com or call our Sales Department toll-free at 888-512-1024 (Mon-Fri, 7am-5pm, PST).

PARALLAX

Download complete documentation, *.wav file speech examples, application notes and technical specifications from our website at **www.parallax.com**.

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